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THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

· NOVEMBER · 1916 ·

ANNUAL MEETING, NEW YORK CITY, DECEMBER 5-8

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OF
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

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INVITATIONS TO ENGINEERS

On December 5 to 8, 1916, there will be held in the Engineering Societies Building, 29 West 39th Street, New York, the greatest gathering this year of American mechanical engineers representing all branches of the profession, the thirty-seventh annual meeting of The American Society of Mechanical Engineers. It is anticipated that this will be the largest meeting the Society has yet held, and the most representative ever held in the history of the mechanical engineering profession in America.

Every member of the Society should make a special effort to attend the meeting, and the Society, in the spirit of its policy of service to the engineering profession, will be pleased to send an invitation to any other engineer. Requests for such invitations may be made on the form below.

The programme of arrangements made by the Committee on Meetings for the professional sessions, and of the social events planned by the New York Section Committee, will be found on page 906 inside.

Features of the programme are the presidential address by Dr. D. S. Jacobus, and reception; eleven varied professional sessions, each for the discussion of valuable papers; a memorial meeting to Dr. John E. Sweet, who called the first meeting of the Society in 1880; an illustrated lecture and a smoker.

Abridgements of papers to be presented and discussed at the meeting are printed inside and will be concluded in the next issue. Engineers interested in contributing to the discussion of these papers are invited to send in their contributions, which will be read at the meeting and published later.

November........, 1916

To The Secretary of The American Society of Mechanical Engineers,
29 West 39th Street, New York.

Please send invitations of the Annual Meeting to

.... (Name)	.... (Address)
.... (Name)	.... (Address)
.... (Name)	.... (Address)

I suggest the following names to discuss papers:

Paper...	Discussor's Name	Address ....
Paper.........	Discussor's Name	Address..... ....

Signed.................. ....

COMING MEETINGS OF THE SOCIETY

Buffalo, N. Y., November 1, 1916. Subject: Motion Study, Frank B. Gilbreth, Mem. Am. Soc. M. E.

New York, N. Y., November 14, 1916. Illustrated lecture on Submarines, by Charles H. Bedell, engineer of the Electric Boat Company of Groton, Conn. (*See New London meeting below*).

Buffalo, N. Y., November 15, 1916. Mr. Russell of the Burgess Aeroplane Company, will speak on an aeroplane topic of general interest.

New Haven, Conn., November 15, 1916. 3 P. M. Afternoon Session, Hammond Mining Laboratory, Mansfield St. Papers: Applied Metallography by Prof. C. H. Mathewson and Testing of Metals by Prof. William Kent Shepard. Discussion will follow.

6 P. M. Dinner at Yale Dining Club, Prospect and Grove Aves.

7.30 P. M. Evening Session, Mason Laboratory, 9 Hillhouse Ave. Papers: Recent Developments in Time Study Devices, F. B. Gilbreth, Providence, R. I.; Processes of Facsimile Reproduction with demonstrations by Samuel J. Berard of the Mechanical Engineering Department of the Sheffield Scientific School. Discussion will follow.

Chicago, Ill., November 17, 1916. Dr. D. S. Jacobus, President of the Society, will speak on Society Affairs; Commandant William A. Moffett, of the Great Lakes Naval Training Station, will speak on Naval Preparedness; Major L. B. Moody, of the Rock Island Arsenal, will speak on Army Ordnance, and Captain J. C. Morrow, Jr., of the Aviation Corps, will speak on Aviation.

Philadelphia, Pa., November 28, 1916. Subject: Aeroplane Engines, Howard Huntington, Secretary of the Aero Club of America.

Buffalo, N. Y., November 29, 1916. Subject: C. H. Bierbaum, Mem. Am. Soc. M. E., will talk on his recent research work on Graphite.

JOINT SECTION MEETING AT NEW LONDON

On November 11, 1916, mechanical engineers in the East—members of the Society's Sections at Boston, New Haven, New York and Worcester and of the Providence Engineering Society—will spend a day at New London, Conn., where special arrangements have been made for a luncheon, an inspection of the plant of the Electric Boat Co., and a trip to the Sound to view an exhibition of naval submarines in action. Particulars will be found on page 905 inside. All engineers—members of the Society, and others—are invited, and all expecting to attend are requested to sign and return the form below.

November........, 1916.

To The Secretary of The American Society of Mechanical Engineers,
29 West 39th Street, New York.

I { will / will not } attend the Joint Section Meeting of the Society at New London, Conn., on November 11, and will join the { Boston-Providence / New York-New Haven / Worcester } party, and will attend the luncheon at Hotel Mohican.

I will have........ guests.

Name..

Address..

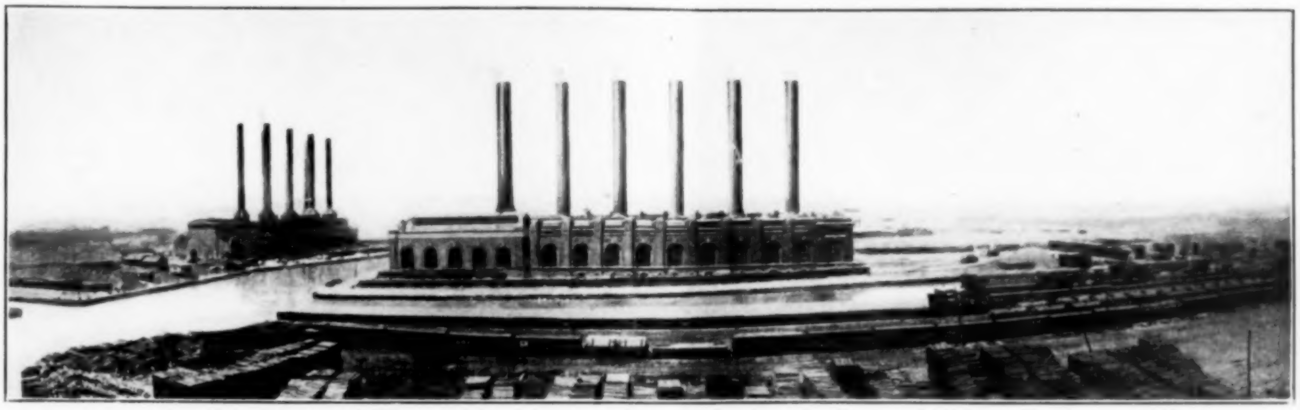

FIG. 1 EXTERIOR VIEW OF FISK AND QUARRY ST. STATIONS, CHICAGO, ILL.

THE PROGRESS OF ECONOMIC POWER GENERATION AND DISTRIBUTION

BY SAMUEL INSULL,[1] CHICAGO, ILL.

THE first part of this paper is devoted to the historical aspect of the generation and distribution of electrical energy, and traces the growth of the industry from the point of view of the apparatus used. This part is of special utility as a source of reference; it is referred to briefly in this abstract.

The second part deals with some of the economic problems in connection with the business, and is of current interest; it is here published in full.

GREAT MODERN GENERATING STATIONS

Fig. 1 gives an outside view of the Fisk and Quarry Street stations on the Chicago River. The large building in the center of the picture is the Fisk Street station and the building on the left is the Quarry Street station. The Fisk Street station was the first large steam-turbine station ever erected. Turbines of a few thousand kilowatts had been put into use by Parsons of England and Brown, Boveri & Co. of Switzerland, and one or two German manufacturers; but this was the first station built for steam turbines alone, and I think it was the first station built by an Edison company using alternating current as the basis of its generation.

The capacity of the Fisk Street station is 165,000 kw., or 247,000 h.p., and of the Quarry Street station is 84,000 kw., or 126,000 h.p. They are both run as one, under one organization, and together have a capacity of 249,000 kw., or 373,000 h.p. I presume that sometime in the next few years those two stations will represent a total of about 500,000 h.p.

To show the magnitude on which the business is conducted, these stations have been run at the highest possible load factor because the apparatus there, up to a short time ago, was the most economical that we had, 3,277,300 kw-hr. being generated in the combined plants in one day. That was on the 24th of December of last year. In the year 1915 the two plants generated 961,818,000 kw-hr., and the total energy generated to date by those two plants amounts to 5,814,162,000 kw-hr. These figures will give you some idea of the enormous production that electrical energy has achieved in the larger cities of the country.

[1] President, Commonwealth Edison Company, Chicago, Ill.

GENERATING UNITS OF FISK STREET STATION

The view presented in Fig. 2 is a view of the first machines that were installed there, so far as their appearance is concerned. At the time we started to build the Fisk Street station we first ordered from the General Electric Company one 5,000-kw. machine. We had expected to put in fourteen machines—say 70,000 kw. We were rather impressed with the Curtis turbine as developed by the General Electric Company. They had an experimental machine of some 250 or 500 kw., and my friend Mr. Coffin, the president of the company, wanted me to give them an order for a machine capable of developing 1,000 kw. I told him that we already had a large number of reciprocating-engine units much larger, and to go to a machine of a smaller size simply because it was novel would be a step backward. He finally agreed to take the risk of building a 5,000-kw. machine if I would take the risk of installing it, the understanding being that if it would not work we were to return it, we to be out the cost of installation and the loss to our business and the General Electric Company to stand the cost of the turbine.

It is rather interesting to note here in New Haven that at that time Professor Breckenridge, who was then the head of the engineering department of our state university (Illinois), assisted us in testing the first units at the Fisk Street station. We put in three units. The first one ran as high as 7,800 kw., and the other two about the same—not because they were intended by the manufacturer to develop that amount of power, but because the necessities of our business compelled us to get all the power out of them that we could generate. Then we installed a fourth machine of larger capacity, of about 9,000 kw., and paid a premium because the machine exceeded the guarantee.

Abstract of address, copyright by Samuel Insull, 1916, delivered at a joint meeting of the New Haven (Conn.) sections of the A.S.C.E., A.I.E.E., A.I.M.E. and Am.Soc.M.E. under the auspices of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, April 5, 1916.

None of those four machines is shown in Fig. 2. The progress of the art was such that with practically the same boiler-room arrangements, a little larger grates, and a little higher stacks, we were able to operate 12,000-kw. units, so we scrapped the first four machines and installed 12,000-kw. units in their place. The view given is that of the later machines. I think that scrapping operation cost us upward of a million dollars, and I think it paid for itself in about three years owing to the advances made in turbine design.

LET THE SHOEMAKER STICK TO HIS LAST

It is rather interesting to note the difference in method of people who run the business of the manufacture of electrical energy as a business and the method pursued by people who run the manufacture of electrical energy as a side-show. One of the most up-to-date steam-railroad systems in the United States today is probably the New York Central line. I think they have two stations equipped with precisely the same kind of apparatus as that which we discarded several years ago.

What is the reason for that? Their business is to manufacture transportation. They might just as well be in the business of manufacturing coal as to manufacture electrical energy. It is a mere side-show with them. True, it has given them less trouble than anything else, but, so to speak, they are letting the water flow over the dam day after day in their electrical apparatus, because it is not their business to get highly efficient results in generating electrical energy.

The way railroad men make their balance sheet show up well is by finding out how to manufacture cheap transportation, whether of dead freight or live freight, and the way we central-station men make our money is by manufacturing cheap energy. I do not know of any better illustration, or any better case where we can (if I may be allowed to use slang) " hand one " to the steam-railroad company and quote the old adage that " a shoemaker had better stick to his last."

Several years ago there came out to Chicago a very distinguished engineering commission for the purpose of gathering information to be used in designing a large plant. This commission decided to duplicate what we had—not what we have—but what we had. And for fear they would not be able to run it they purloined one of our men to run it, and they are still running it. What they copied has been in the scrap heap for years. I think one of the machines which they copied is erected in the yard of the General Electric Company at Schenectady as a sort of relic of ancient history.

RUNNING INTO LARGE FIGURES

Fig. 3 is a view of one side of the boiler room of one of our stations. If we had a complete view of the room you would see that the chutes carrying coal down on each side give quite a Gothic appearance to the room. The number of boilers is five. The heating surface for each boiler is 12,200 sq. ft.; superheat, 200 deg. fahr.; steam pressure, 250 lb. per sq. in.; capacity in pounds of steam per hour for each boiler, 50,000 lb. For all five boilers 60,000 lb. of coal an hour is required.

A view of a turbo-generator erected in the Northwest station, Chicago, is given in Fig. 4. It is of 25-cycle, 9,000-volt, 30,000-kw. capacity; total weight, 590 tons; length over all, 60 ft.; width, 19 ft.; r.p.m., 1,500; peripheral speed of revolving field in ft. per min., 20,000. That class of apparatus has taken the place of the vertical turbine shown in previous views.

Our practice is to run a machine of that character practically all the time. We get the best results and the lowest repair costs if it runs continuously, provided it is shut down

FIG. 2 TURBINE ROOM, FISK ST. STATION, CHICAGO, ILL.

a few hours a week to see that everything is in order. It is a class of machine which is being very largely used at this time and represents the most modern development.

kw.; 1902, 3,500 kw.; 1903, 5,000 kw.; 1915, 35,000 kw. That represents the progress that has been made. If there had been room on the diagram, we could have started out with the

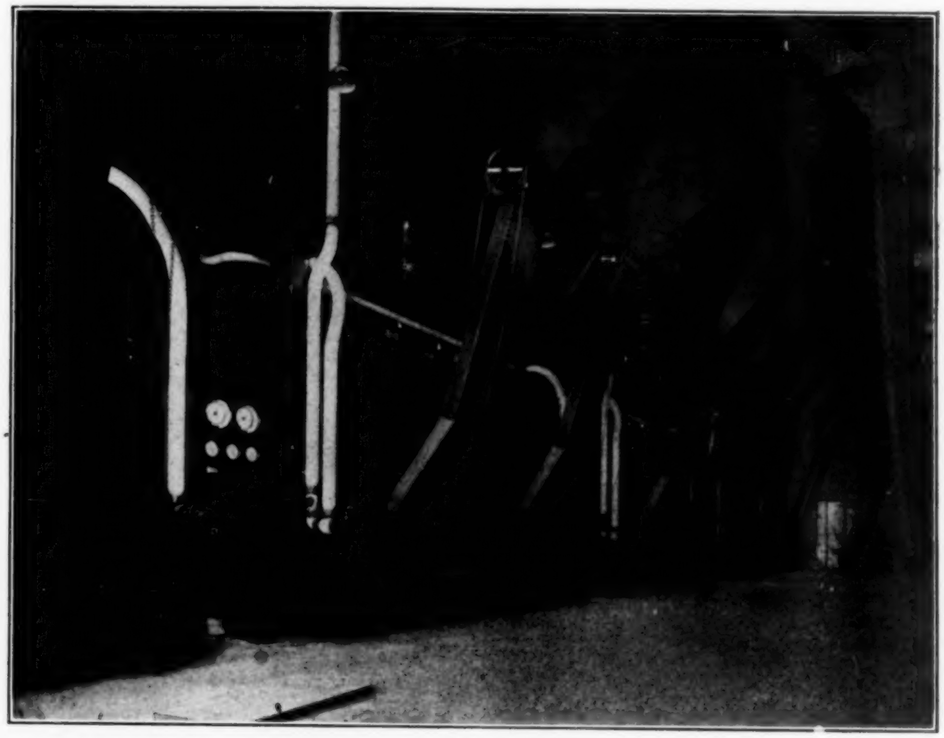

FIG. 3 BOILERS SUPPLYING 30,000-KW. UNIT, NORTHWEST STATION, CHICAGO, ILL.

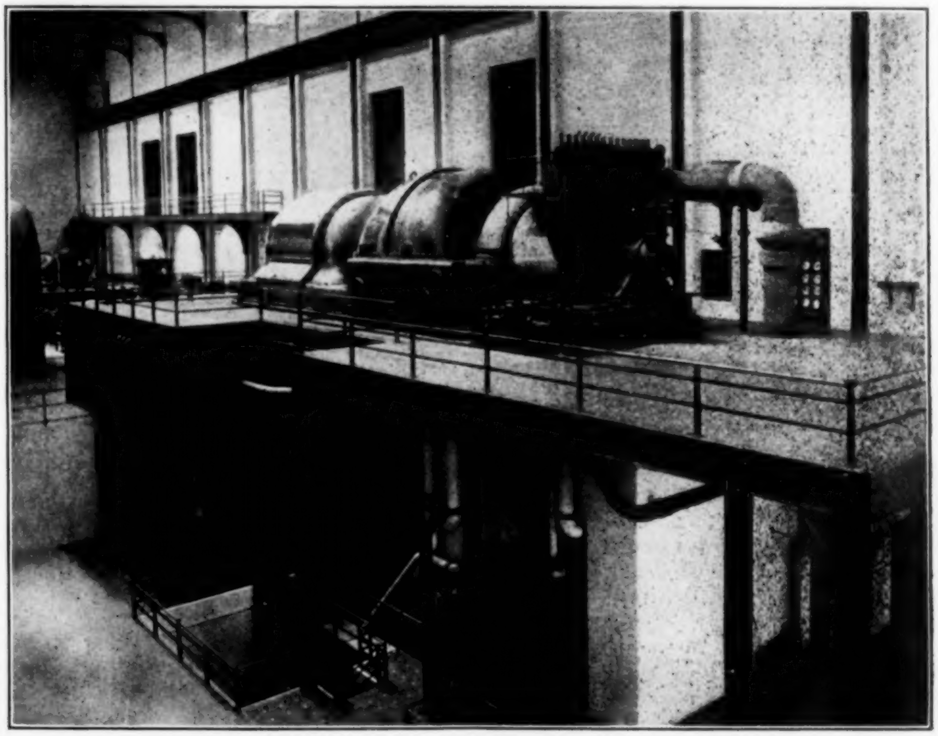

FIG. 4 30,000-KW. TURBO-GENERATOR, NORTHWEST STATION, CHICAGO, ILL.

The diagram of Fig. 5 represents the capacity of generating units at various dates, and gives some idea of the progress in the massing of production of energy. In 1887, 160 first direct-connected unit of 1881 of about fifty kilowatts.

I shall come back to this subject later on in the course of the address.

TAKING ADVANTAGE OF DIVERSITY OF DEMAND

A load diagram of the maximum day of the winter of 1915-1916 is given in Fig. 6. It shows the relative amounts of electrical energy supplied to street and elevated railways and for light and general power purposes in the city of Chicago. The light and power business took 147,300 kw. on the 29th of November, 1915, which was the day of the coincident maxima data. The railways took 190,600 kw. on the same day, a total for both of 337,900 kw. The non-coincident maxima for that winter came on the 22nd of December, 1915, in the light and power business when that business took 155,670 kw. The date of non-coincident maximum of the railway business came on January 6, 1916, when that business took 203,560 kw. So that we took care of the non-coincident maxima of the two branches of our business (359,230 kw.) with a total for the coincident maxima of 337,900 kw. This shows a diversity of

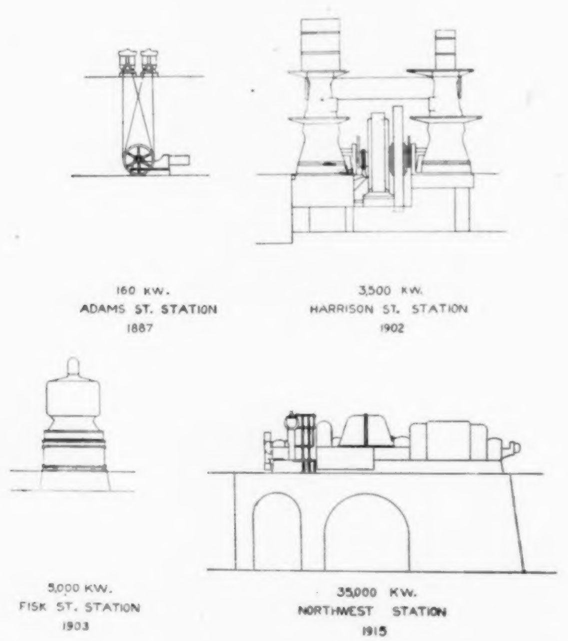

FIG. 5 RELATIVE SIZE AND CAPACITY OF GENERATING UNITS, CHICAGO, ILL.

21,330 kw. As I shall show you later on, one of the tendencies of the massing of production is to increase the diversity.

The drawing shown in Fig. 7 is the load diagram for the maximum day, and shows the Chicago curve for 1894 and one for a large city without the railway load prorated to the Chicago 1915 maximum curve for comparison. The annual load factor for Chicago in 1915 was greater than that of Chicago for 1894 by 68.5 per cent, and was greater than that of the large city in 1915, without the railway load, by 23 per cent.

I think on this load diagram you can find pretty good proof of the desirability of massing production and distribution. In 1894 the Chicago business showed a 25 per cent load factor. An eastern city having a great many advantages in the light and power business which we do not possess in Chicago, showed a 35 per cent load factor in 1915. Chicago, doing a wholesale and retail business combined, in 1915 showed a 43 per cent load factor. A reference to the diagram shows where the increase comes in.

Fig. 8 gives you a comparison of the summer and winter business of the energy supply to street and elevated railways. It shows that the winter demand is 35 per cent greater than that of the summer.

USEFULNESS OF ALTERNATING CURRENT

In the early days of this business of producing and distributing electrical energy, we were confined to very small

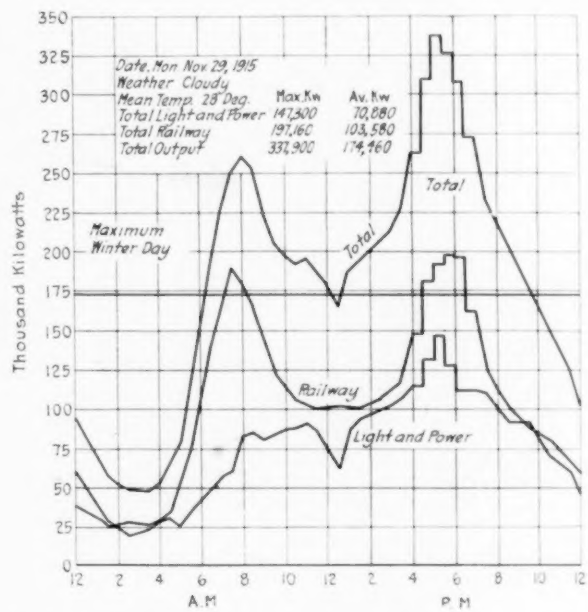

FIG. 6 LOAD DIAGRAM, MAXIMUM DAY, WINTER 1915 AND 1916, CHICAGO, ILL.

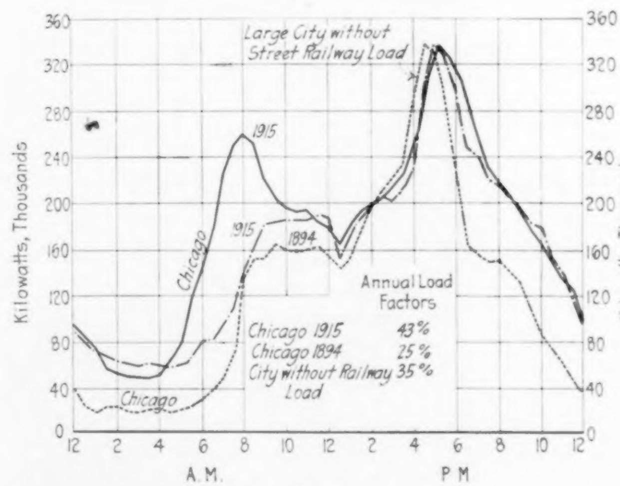

FIG. 7 LOAD DIAGRAMS FOR MAXIMUM DAY, CHICAGO, ILL.

areas—probably about 2,500 ft. in any direction from the generating plant. Unless we used expensive apparatus, such as boosters and very large feeders requiring a very heavy investment, it was difficult to get a direct-current system beyond 2,500 ft. in any direction, or say about a mile square.

Then the alternating-current system came along, and that did not fill the bill. There were disadvantages in the early apparatus. Owing to the smallness of the units, the cost of production was very high. We had made greater advances

really in the steam engineering and in the electrical engineering of the direct-current system than was made for a number of years by the alternating-current people. We people who had been very much wedded to direct-current production and distribution were casting around for means of economic transmission.

We were forced to the use of alternating-current feeders by the development of the marine type of engines with direct-connected dynamos, leading to the building of units running

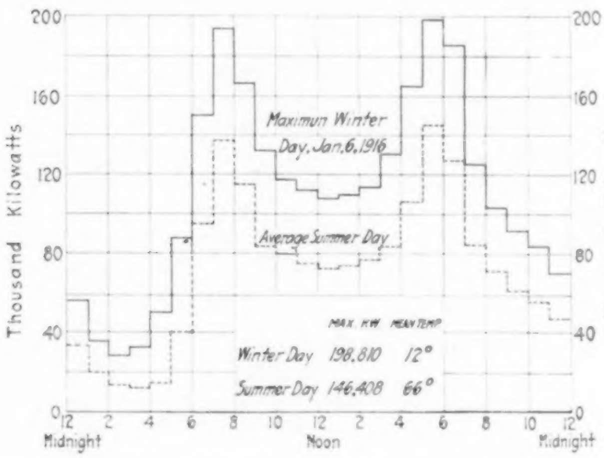

FIG. 8 LOAD DIAGRAMS OF COMMONWEALTH EDISON COMPANY, CHICAGO, ILL., FOR STREET AND ELEVATED RAILWAYS

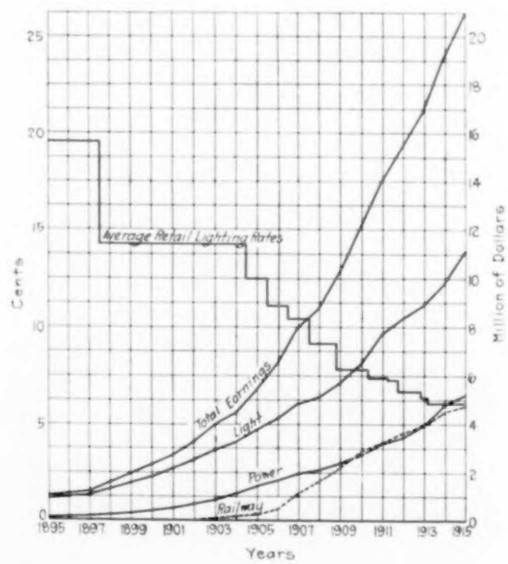

FIG. 9 EARNINGS FROM SALE OF ELECTRICITY AND REDUCTIONS IN LIGHTING RATES, CHICAGO, ILL.

up to 3,000 and 4,000 and 5,000 kw. We were forced to take advantage of this system of transmission, many of us very unwillingly, because we at that time had great prejudices against the alternating-current system. We used to give it the name which is used with reference to some of the apparatus now used in the war, that is, "baby killer." And some of us used to point to the practice in several of the states of "electrocuting" criminals by the alternating current to show what a terrible thing the alternating current was. But as steam engineering progressed, as we got more economical units, we were forced to use the alternating-current system for generating and transmission purposes.

IMPROVEMENTS IN THE APPARATUS

The apparatus was very uneconomical at the start. Some of us used rotary converters, some of us used motor-generators, but they were nearly all of them uneconomical at the start. The improvements in both classes of apparatus led to a very great extension of the use of the alternating current. But the thing above everything else that has led to the mass-

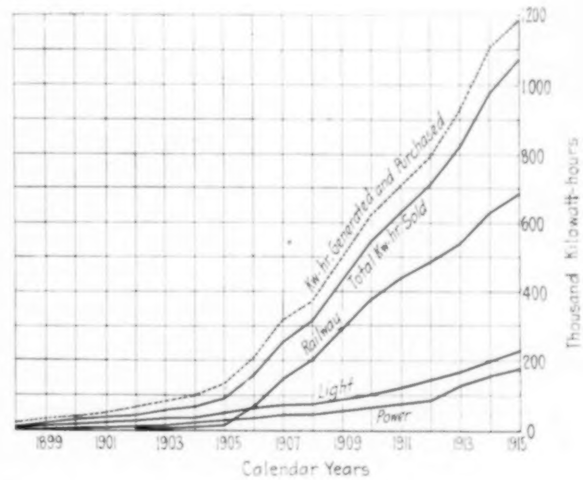

FIG. 10 KILOWATT-HOURS PRODUCED AND SOLD, CHICAGO, ILL.

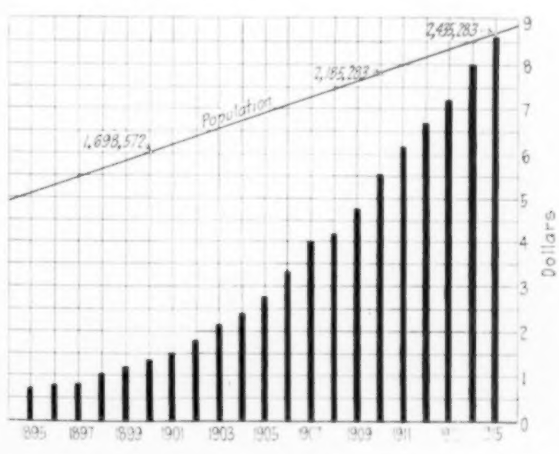

FIG. 11 EARNINGS FROM SALE OF ELECTRICITY IN CHICAGO, ILL., PER CAPITA, 1895 TO 1915

ing of production of energy for all purposes is the introduction of the large steam turbine. With the reciprocating engine we could not get much above 4,000 or 5,000 h.p. There may have been a few units made of 5,000 kw., but very few indeed.

But when the large steam turbine was produced, with its great economy, both in its cost of installation and cost of operation, we were forced still further to take advantage of alternating-current generation and alternating-current primary distribution, so that today no one thinks of building a direct-current station for use where any large amount of energy is required over any extended area.

I think, next to the invention of the original direct-current distribution system and the original invention of the alternat-

ing-current system, that probably the thing that has had the greatest influence on the development of this great industry, which today is becoming not only state-wide but almost nation-wide in its character, is the development of the large steam turbine.

A NOTE OF WARNING AS TO SIZE OF UNITS

Probably there is no better time than this to sound a note of warning to those who are carrying the development of prime movers to very large sizes. To those of you who are familiar

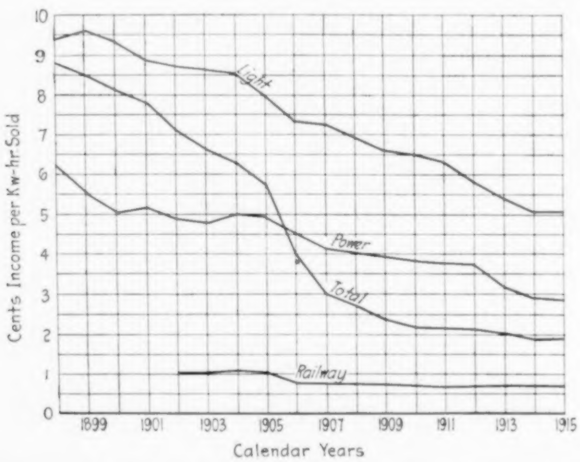

FIG. 12 INCOME PER KILOWATT-HOUR SOLD IN CHICAGO, ILL.

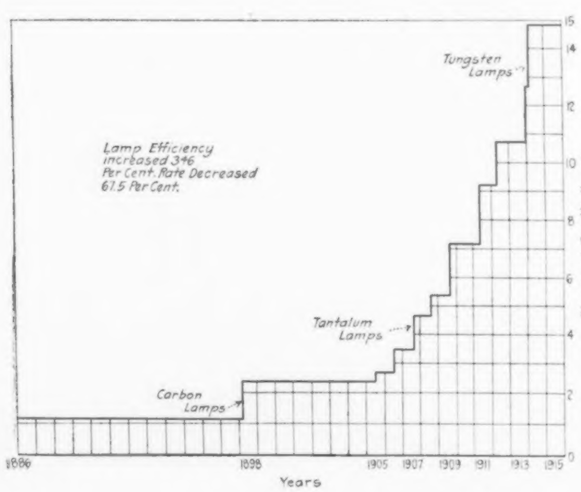

FIG. 13 AMOUNT OF ELECTRIC LIGHT ONE DOLLAR WOULD BUY IN CHICAGO, ILL., 1886 TO 1915

with the course that I have pursued myself in connection with the development of the enterprises under my control, it may seem rather unusual for me to sound a word of caution on size. But it does look to me as though a great many of the managers of the systems in different parts of the country are allowing their engineers to order turbines of a size out of all proportion to their requirements, and having no relation to the load which they have to deal with, and that if such a course is unwarrantably pursued it must inevitably lead to disaster in some of the great distribution systems of this country.

I heard the other day of a man who is installing a large turbine for more than 50 per cent of his load. There is absolutely no justification for such a course. I do not myself think that it is safe to order a unit for much more than say 10 to 12—and at the very extreme 15—per cent of the total demand on any one system. There are cases where it is not possible to confine oneself to that percentage; for instance, where turbines for new systems are being ordered. But I refer to cases where old systems are in existence, and there is not any justification for the very large turbines; and I would make the suggestion, particularly at this time when the cost of material is so great and when it is impossible to get the views of the best people on both sides of the Atlantic, that the operators of large systems would do well to call a halt in building larger sizes of turbines.

At the present time about 35,000 to 40,000 kw. is the largest size that can be obtained. I have heard of some orders being given for 50,000-kw. machines. I am rather sorry to hear it, because I think the buyers will regret it. Before we need the larger size we will need higher boiler pressure, which will first require expensive experiments in boiler construction, and we will need a great many changes in the details of apparatus used in connection with large turbine units; and I think that the progress of the next few years will be the better made if it is the slower made.

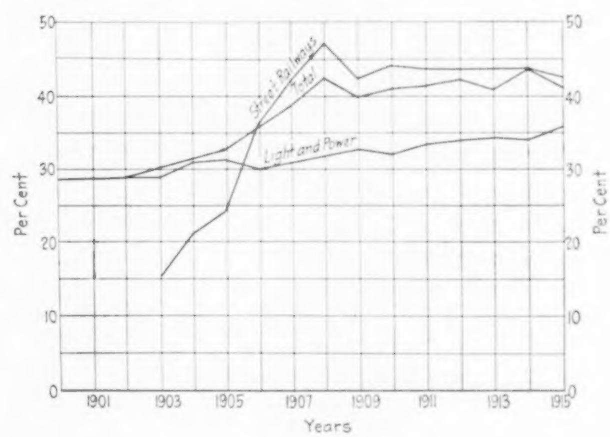

FIG. 14 ANNUAL LOAD FACTORS OF COMMONWEALTH EDISON COMPANY, CHICAGO, ILL.

I am sure that if those who are connected with any large system will follow up my suggestions as to the desirability of standing still a little while, they will find that in the course of the next few years they will be a great deal of money in pocket. I am giving this form to my views on the subject because I am generally credited with employing the largest apparatus that can be obtained.

THE ENGINEERING OF SELLING

Having true engineering of construction as a basis, we come to another side of the business; that is, the engineering of selling.

This diagram (Fig. 9) shows that, starting in 1896 with a gross business in Chicago of about $1,000,000, and increasing, year by year, we had in 1915 a total business of almost $21,000,000, divided as follows: Light, a little over $11,000,-000; power, a little over $5,000,000; and the supply of energy for transportation purposes, a little below $5,000,000.

Fig. 10 is a chart of kilowatt-hours produced and sold. It is interesting to note how closely the output figures follow the figures of money. You will notice that the curves on this

drawing follow very closely the curves on the previous one (Fig. 9), so far as the total is concerned, but with a much sharper line so far as railways are concerned. The cause of this difference between the two curves, that is, the money curve and the output curve, is the fact that in the development of our business we have probably carried to a greater extent than the majority of electric-service corporations the wholesaling of energy for transportation.

Fig. 11 gives you an idea of the increase of the earnings from the sale of electricity per capita from the years 1895 to 1915 in the city of Chicago.

LOW PRICE OF ELECTRIC LIGHT AND POWER

The income per kilowatt-hour sold is given in Fig. 12. The income from light shows a steady drop per unit sold from 1898 to 1915, amounting to about 46 per cent in price per kilowatt-hour sold. The power income follows somewhat the same curve. It started at a lower price and necessarily ends at a lower price. The wholesaling of energy for transportation purposes runs along on a very steady line. In the first three years the price did not vary. As the business developed the price dropped in 1906, and that price continues practically up to the present time, and is on a basis lower than it is possible for the local transportation companies of Chicago to produce their energy themselves. The price per kilowatt-hour in 1915 was 16 per cent lower than in 1908. This difference is not apparent in the curve on account of the scale used.

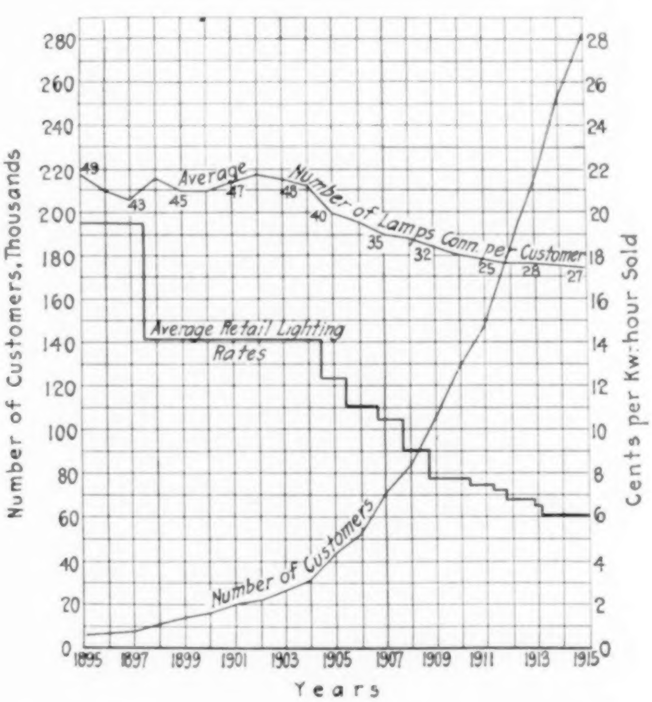

Fig. 15 Reduction in Lighting Rates, Average Lamps per Customer and Number of Customers, Commonwealth Edison Company, Chicago, Ill.

Fig. 13 gives you an idea of the amount of electric light one dollar would buy in the years from 1886 to 1915. This chart shows graphically the great reduction in the cost of electric light to the average small user. The quantity that one dollar will purchase is now six times as large as it was ten years ago.

A chart of the annual load factors of the Commonwealth Edison Company (and its predecessors) for the last sixteen years is presented in Fig. 14. You will notice that the street-railway load factor went up and then dropped. It was at its highest for a few years just before one of the large street railways shut down its obsolete stations, which it had operated as "peak plants" only. This shutting down had also the result of earning it a very low price for the energy it purchased. The tendency of the railway load factor is to run even. The tendency of the light-and-power load factor is to improve. For 1915 the combined load factor was 42.5; the light and power 35.8, and the street-railway business by itself 41. The improvement in the two combined is owing to the diversity.

A diagram showing the reduction in lighting rates, the average lamps per customer and the number of customers is given in Fig. 15. The chart shows that as the rates for electricity have been reduced the number of customers has increased enormously and the average size of the customer's installation has grown smaller. Electric light, instead of being a luxury, as it formerly was, is now the cheapest illuminant.

WHAT BECOMES OF THE DOLLAR OF INCOME

Fig. 16 is an instructive chart showing what becomes of the dollar of income; and I venture to say that the figures given here are relatively about the same whether it is in a large city like Chicago or in a smaller city like New Haven.

Fig. 16 The Dollar of Income and What Was Done with It in 1915, Commonwealth Edison Company, Chicago, Ill.

While it is not my function to discuss political questions, one of the serious questions of the day is the view that a great many young men going out into life have regarding the large enterprises of the state. Their opinions are very largely based upon the statements of able writers who have great facility of expression but who are untrammeled by responsibility of position.

If you were to come out to Chicago, the long-haired talker, the long-haired reformer, would talk about the earnings derived from our investment in a way most unfriendly to the public-service corporation; he would tell you that the rate we charge is ten cents, whereas this is our maximum rate. But I want to tell you that of every dollar we receive, seven per cent of it goes back into either the municipal or the state treasury, and that, as a matter of fact, when our patrons are

paying us a dollar they are indirectly being taxed seven per cent of that dollar in the form of what amounts to double taxation.

ELEMENTS OF COST

If that long-haired reformer happens to be an advocate of municipal ownership, he will not tell you that no allowance is made by the municipal plant in this city or that city to compensate for the sum paid by the public corporation in the shape of taxes and compensation. Now take the size of these various sections (see Fig. 16). You will see here that that part of the capital which is obtained on a low-interest basis because it has a prior lien does not get very much more out of the business than the amount that has to be paid for the privilege of doing business; and bear in mind that the corporation does not pay for that privilege. Our customers pay for that privilege, as it is figured in the cost of energy.

We are a regulated monopoly, a partial monopoly, as a rule, but we are regulated, as our rate for energy is settled by a state commission, based upon our cost and a reasonable return on our property, and to that is added the taxes and municipal

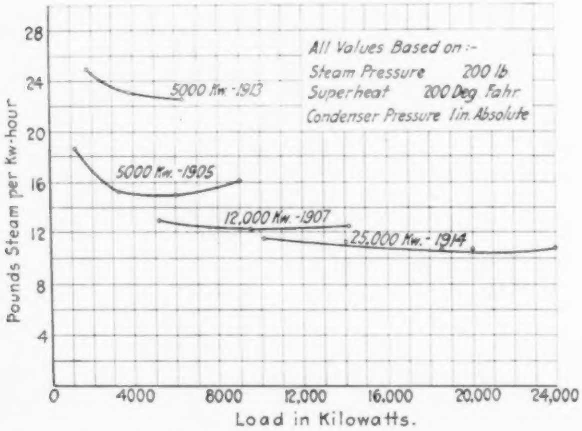

FIG. 17 STEAM ECONOMY TESTS OF STEAM TURBINES

compensation, so that the people who pay that are not our 2,500 stockholders, but our 250,000 customers.

The people who take the greater risk and who put their money into stock, into the junior securities of the company, only get a little over twice as much on the operation as the community gets for the right to do business. Those irresponsible heads of organizations who like all the privileges but none of the responsibilities of government always want to take care of labor; but out in Chicago all that they allow us to pay labor is about twice as much as our customers pay the community for our right to do business with them.

Fuel is supposed to be a very important portion in our cost. We consume thousands of tons of coal per day, and yet our total coal cost is less than double what our customers pay to the community for giving us the privilege to do business. And so on all the way round.

STEAM-TURBINE EFFICIENCY

An interesting chart in relation to the steam-economy tests of various turbines is shown in Fig. 17. These curves show that in 1903 the design of the steam turbines then available was such that the water rate was 22.5 lb. per kw-hr. The machines of that period had two wheels with four rows of buckets to each wheel. It was, therefore, necessary to expand the steam considerably in the first nozzles to get sufficient velocity so that the energy generated could be absorbed by the two wheels. This high velocity meant, of course, considerable friction loss.

In 1905 improvements in design reduced the water rate to 15 lb. per kw-hr. under the most economical load on the machine. In 1907 five wheels were used, there being two rows of buckets for each wheel. Consequently, the lower velocities from the nozzles reduced the friction losses, giving a water rate of about 12.3 lb. per kw-hr. Still further improvements

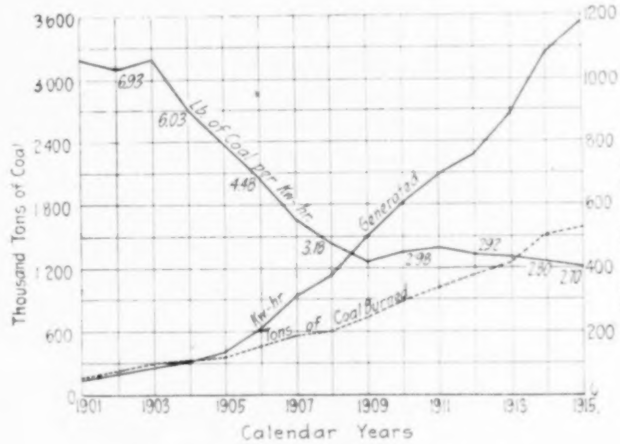

FIG. 18 "CONSERVATION OF COAL"

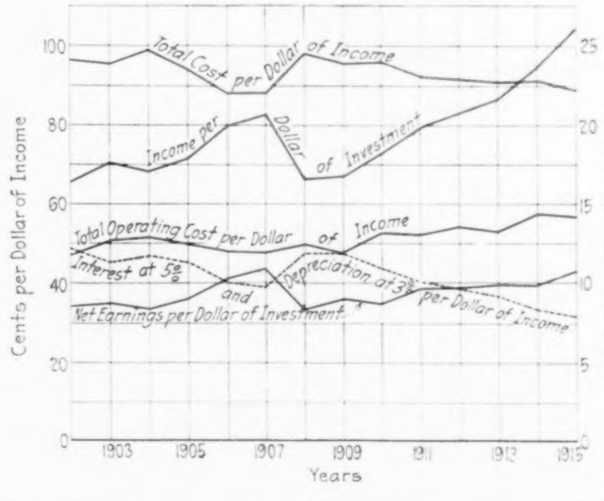

FIG. 19 FINANCIAL CHART NO. 1, COMMONWEALTH EDISON COMPANY, CHICAGO, ILL.

were made in the 1914 design. The number of wheels was increased to ten. With more correct bucket shapes, and with one row of buckets for each wheel, the water rate was still further reduced. The curve for this machine is not shown, as it coincides very nearly with the curve labeled "25,000 kw." in Fig. 17. This curve is for a turbine of the reaction type. The preceding remarks apply to machines of the impulse type. As its name implies, the reaction turbine employs the principle of reaction, its evolution being very similar to that of the impulse machine.

Those last curves are, I think, indicative of the progress which has been made in the efficiency of the steam turbine during a period of over eleven years.

CONSERVATION OF FUEL

Fig. 12 shows the other side of that same subject, that is, the conservation of fuel. Here is shown the drop in the pounds of coal per kilowatt-hour produced, starting at nearly seven pounds per kilowatt-hour and going down to 2.70 lb. Another curve shows the kilowatt-hours generated, and a third the tons of coal burned.

The diagram is indicative of what we have been able to do in the direction of conservation of coal. That results partly from the improvements in the prime movers, partly by the shutting down of small uneconomical stations, and the massing of production and distribution over very much wider areas.

I think that while a great many of our well-intentioned friends have been shouting about the conservation of natural resources, the steam-turbine inventors and the designing engineers of the great power companies using steam as a prime source of power have probably done more to conserve the natural resources of this country, in so far as fuel is concerned, than has been done by all the agitation that has taken place upon the general subject of conservation.

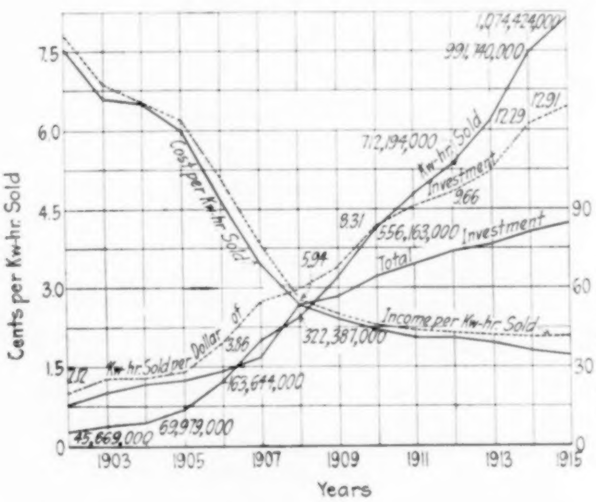

Fig. 20 Financial Chart No. 2, Commonwealth Edison Company, Chicago, Ill.

It is interesting to note that the saving in Chicago per unit for the fourteen years from 1900 to 1915 was equivalent to a saving for the year 1915 of 2,472,400 tons, or 58,000 carloads of coal per year, or fourteen loads of forty cars each per day.

FINANCIAL DATA AND STATISTICS

Fig. 19 gives you some financial figures—the total cost per dollar of income, the income per dollar of investment, the total operating cost per dollar of income, and the net earnings per dollar of investment.

Some more financial information in another way is presented in Fig. 20. This gives cost and income per kilowatt-hour sold. To the cost is added the necessary allowance for interest and depreciation. You will see how closely the cost and the income follow each other during a period of from 1902 to 1915. The kilowatt-hours sold per dollar of investment are also shown in Fig. 20. When we were doing but a small wholesale business we used to sell only two kilowatt-hours per dollar invested. Now we sell thirteen kilowatt-hours per dollar invested.

A very interesting diagram showing the diversity of large light-and-power customers is that of Fig. 21. It has always been assumed until this particular investigation was made that the maximum demand of manufacturers and large users came at about the same time, but Fig. 21 shows this is not the case.

POSSIBILITIES OF THE FUTURE

Now as to the possibilities of this class of business. You will have to excuse me for referring so much to Chicago, but I have more definite information regarding the city of Chicago than I have in regard to any other place. The light-and-power business of the Commonwealth Edison Company is approximately 338,000 kw.; that of isolated plants is 264,500 kw., and that of the steam railroads is 125,700 kw., making a total of 728,200 kw.

Our estimate is that at the present time we are doing about 46 per cent of the total possible business in the city of Chicago, and that if we had the entire possible business, instead of running at a load factor of 40 or 41 per cent, we would probably have a load factor on the entire system upwards of 50 to 60 per cent.

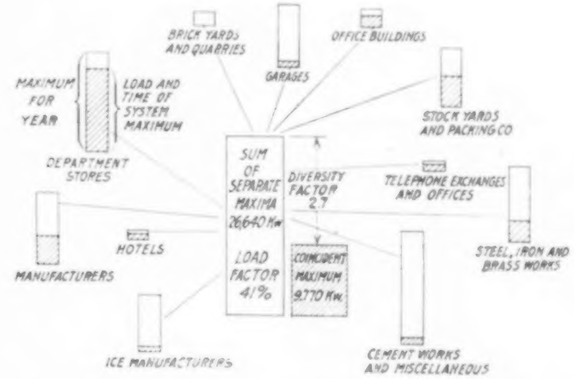

Fig. 21 Diversity of Large or Wholesale Light and Power Customers

What does that mean? Broadly speaking, it means that the cost of carrying the necessary investment for a city of two millions and a half of people, that is, the interest cost and the depreciation cost of carrying the entire investment, if all the energy is produced under one organization, would be reduced approximately 33 1/3 per cent. That would indicate that at the present time where any form of energy is required —I do not care whether by steam or electricity or how it may be obtained—it is an economic waste for the individual spending the money to try to produce that energy in a small way, and that the true function of the large electric-light-and power companies of this country is to produce all the energy that is required in the community. In these days when so many of our operations between the cradle and the grave are being regulated I am somewhat inclined to think that the day will come when one of the regulating bodies will step in, insist on all energy being produced from central generating plants and tell the people who are guilty of economic waste that they must stop. Such regulating body will say that the country cannot afford to have them throwing away money, which indirectly must be sapping the country's wealth, as if

equipment is employed unnecessarily, if fuel is wastefully employed, if labor is wastefully employed, all those things must be harmful to the general wealth of the state.

BROAD ASPECT OF THE QUESTION

I firmly believe that the doctrine that it has been my privilege to preach for a good many years, and which I am glad to say is becoming more popular—that is to say, the massing of production, the massing of distribution, the selling of energy for all kinds of purposes on a very large scale from one system—I firmly believe that in advocating that course, while I am advocating a course that is very advantageous to the class of property that it is my privilege to have charge of, at the same time I am advocating a course that is very advantageous to the whole community and to the whole state.

To give you some idea of how these figures mount up I have had worked up the data derived from Census statistics on the same basis on which we have worked it out for the city of Chicago, and applied it to the whole country. Supposing we take all the settled areas of the United States wherever there is great density of population, practically everywhere this side of the Mississippi and practically everywhere the other side of the Rocky Mountains (all you have to leave out is the desert country and the purely agricultural country), and let us assume that all the work is done electrically. Let us assume that every part of the country where the density of the population justifies it, whether it is in a community or whether it is state-wide, or whether it occupies a larger area and goes beyond the confines of a state—let us assume the electricity supply business is all put under a series of central organizations, and what do we find?

GREAT SAVINGS THAT COULD BE EFFECTED

We find that it takes about 68,000,000 to 70,000,000 h.p. of non-coincident demand; that the coincident load would be about 47,000,000 h.p., and that the diversity would be upwards of 20,000,000 h.p. If you will capitalize the labor that would be saved; if you will figure the investment cost of the 20,000,000 of h.p. that would be saved; if you will figure out the value of the fuel that would not be used—the savings are staggering; and the possibilities that this business offers are almost beyond the dreams of the most enthusiastic figurer.

I happened to learn only a few weeks ago of a case in a city not very different from any other city and not a very large city, in a territory where the population is not so dense as it is in this Connecticut country, and where the amount of energy used is not as great. In the city itself the electrical interests, both for light and power and for transportation, are in one organization. Outside the city, in the surrounding territory, most of the light and power and transportation interests are in another organization. In the city the maximum load comes in the afternoon. In the surrounding territory the maximum load comes in the morning. In the city they, so to speak, allow the water to flow over the dam all day long except in the afternoon, and outside the city they allow it to flow over the dam all day long except in the morning.

If you will capitalize the saving in operation in just that one district, with a population relatively small, and add the saving in investment that would take place by combining the generation of energy in that small piece of territory of about 100 square miles, the saving will be between six and seven million dollars.

WHERE THE REAL DANGER LIES

Yet some persons would tell us that if that is allowed to be done it will produce a combination that may be dangerous to the state. It is not dangerous to the state to let the money go to waste, to waste its resources and its capital; but it is said to be dangerous to the state to allow an organization to double its size, even though that organization is regulated by a commission of the state appointed or approved by the state Legislature. I think that is the kind of danger to the state that I shall have to spend my days in advocating as long as I live; I think that it is to the highest possible advantage to the state, that it is a real contribution to the better management of the country's affairs. In closing I cannot do better than to tell the young men here who are expecting to make the class of business with which I am proud to be associated their life's work that I do not know of any business in this country in which there are greater possibilities, greater opportunities, for men not only to serve themselves but to serve their fellows. I know of no walk in life, public or private, in the industrial world, in which there are greater possibilities of national advantage and community advantage than in the business that I have tried to tell you something about this evening.

It is a question of some interest as to how far the continued combustion of mineral fuels will so alter the quality of the atmosphere we breathe as to lower the vitality of the human race as at present constituted. The total weight of the carbon in the coal, oil, gas and peat resources of the globe is estimated at something like 6,400,000,000 tons, requiring twelve times that weight of air for its complete combustion. A calculation shows that the weight of the atmosphere is nearly 150 times the weight of the air needed for the combustion in question, and that the weight of the resulting carbonic acid gas would be but 0.22 per cent of that of the atmosphere, or less than one-fifth the percentage allowed by the Mines Regulation Act. —Arnold Lupton in *The Iron and Coal Trades Review,* July 28, 1916.

According to Kelvin's law, maximum economy in electric transmission is obtained when the annual interest and depreciation charges equal the cost of the energy loss. This law, however, does not allow for additional capacity in lines to care for future growth in business nor for voltage regulation; hence it does not hold good in practice today, where experience shows that both of these provisions are necessary for the highest economy ultimately.—Geo. P. Roux, in *General Electric Review,* Oct., 1916.

An investigation of the markets of South America for construction materials and machinery is being undertaken by the Bureau of Foreign and Domestic Commerce, U. S. Department of Commerce. The investigation will cover construction materials, with especial attention to cementing materials, clay products, steel products, wrought iron, steel and case iron pipes, valves and fittings and heating installations. With reference to construction machinery it will include power shovels, drills, derricks and hoisting apparatus, cableways, pumps, pile-driving machinery, mechanical mixers, floating equipment, road-making machinery, and construction tools.

THE SALES ENGINEER AND HIS RELATION TO PRODUCTION AND MACHINE DESIGN

By ARTHUR J. BAKER, CINCINNATI, O.

Member of the Society

The function of the Sales Engineer, as stated by the author, is to study the requirements of the users of the machines made by his concern in order to discover what modifications of standard types and what auxiliaries in the way of jigs, fixtures, etc., are needed to effect an increase in production or decrease in installation cost, and to meet the competition from another type of tool as well as the peculiar conditions presented by novel machining problems.

The gradual development of the sales engineer from the old-time machine-tool demonstrator, and the beneficial effect of his services both to manufacturer and customer are dealt with at length in this paper, and several concrete illustrations of the methods employed are given.

The paper shows that the sales engineer has already had a positive influence on future design of machine tools, and that the knowledge his methods have brought out has been so utilized as to make it valuable for future research.

THE title, Engineer, has already been subjected to so many prefixes, that one hesitates to add another to the already confusing number. There seems, however, hardly any other term than that of Sales Engineer which quite so well defines the activities of that growing class of engineers with whose influence on design and production it is proposed to deal.

As one views the progress of machine-tool design, one cannot help but feel that it has been largely left to the user of a machine to indicafe the changes which would make the machine more particularly suitable for his class of work, and that the designer and maker of the machine have generally been the second party in such improvements. I do not, of course, here refer to detailed improvements, particularly in regard to the construction of the machine, but rather to those pronounced departures from type that may be said to mark the advances in the art; in other words, it would appear that the majority of the engineer-designers of most machine-tool factories have for many years been working on improvements of well-defined types of machines, and cannot have made that rigid investigation of the conditions which govern the use of such machines that would seem to be absolutely essential if ideal conditions are even to be aimed at.

There are, of course, very strong commercial reasons from the manufacturer's standpoint for standardizing the design of machine tools. There is further, from the user's viewpoint, that excellent reason relating to the ability of the average operator to handle, with the minimum amount of individual instruction, any machine of the class in which he claims proficiency. Probably in the last analysis this would also be regarded as a commercial reason, but it must also be taken into account in view of the apparent tendency toward the increased employment of unskilled help and the comparative difficulty of obtaining that *rara avis* which used to be known as an all-round machinist.

The user of a machine tool has of late either grown, or been educated, to demand of the machine-tool manufacturer a specific study of his (the user's) requirements. These studies have influenced the design of the manufacturer's product, and will influence it more markedly in the future. The "service" plan, which covers many trades, has developed into an important factor in machine-building organizations.

This condition has led to what I termed the Sales Engineer. His predecessor was the original demonstrator, who, it will be remembered, was and still is a man unusually skilled in the use of the machine which he demonstrates and who is sent out to break in the workmen and to assist the customer in obtaining high production from the newly installed tool.

These demonstrators in their visits to the different plants accumulated considerable experience in regard to the uses and weaknesses of their machines; and, following the natural onward tendency, they were in some cases replaced or augmented by engineers whose duties were not in any way connected with the demonstration or practical operation of the machine, but consisted rather in systematic observation of the uses to which the machine was put. These observing engineers, carrying back to the factory their authentic data, were able to influence materially new designs. They were still, however, concerned only with the standard type of machine and were only brought into contact with the customer's requirements after the machine was installed, and usually after some trouble had developed.

The original machine designer usually devoted himself so closely to his own particular machine that he was not thoroughly in touch with developments taking place in other classes of machines. Even today, in the great majority of cases, that condition prevails. The sales engineer, on the contrary, being brought directly and frequently in touch with the latest installations of such machines, immediately returns to the factory with advance information of the encroachments that the new type of machine is making on his own field. The designing department, lacking a detailed acquaintance with the latest usage to which machines are put, loses its proper perspective in regard to the relative time values of the different functions of the machine. The sales engineer, with any reasonably well-developed analytical faculty, can clearly see that a certain portion of the operation consumes more time than is really necessary, that the output is governed by this factor, and advises the home engineer of the need for improvement in this respect. Furthermore, continuous travels throughout the various shops must of necessity bring him into close contact with those home-made devices which are so often the basis of permanent improvements in standard design. It is idle to suppose for a moment that such improvements are found only in the larger shops, to which unfortunately the

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visits of the sales engineer are usually confined. More often it will be found that the small shop, with its limited equipment, will have evolved some ingenious and interesting method of producing the desired results, where the larger and wealthier shop has been content to increase its quota of standard machines.

While the influence of the sales engineer on the design of his company's product cannot fail to be very marked, it may even be of more vital and material interest to the customer. The general adoption of this sales-engineering system immediately places at the disposal of the machine user a corps of highly trained engineers, whose collective abilities are likely to greatly exceed those over which he would normally have control. Their advice and recommendations should lead to the scientific selection and installation of machines, resulting in a lessened installation outlay and a greatly increased production.

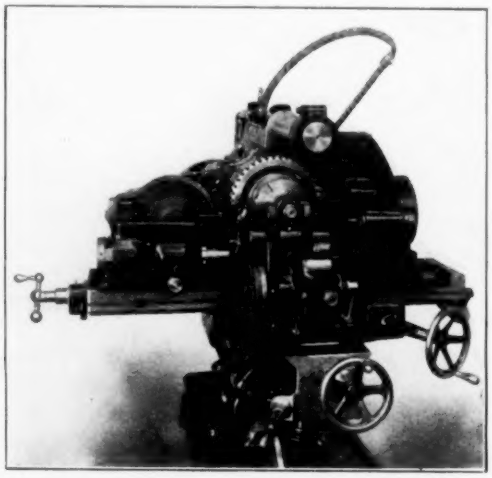

FIG. 1 MILLING MACHINE WITH SPECIAL EQUIPMENT MORE EXPENSIVE THAN MACHINE PROPER

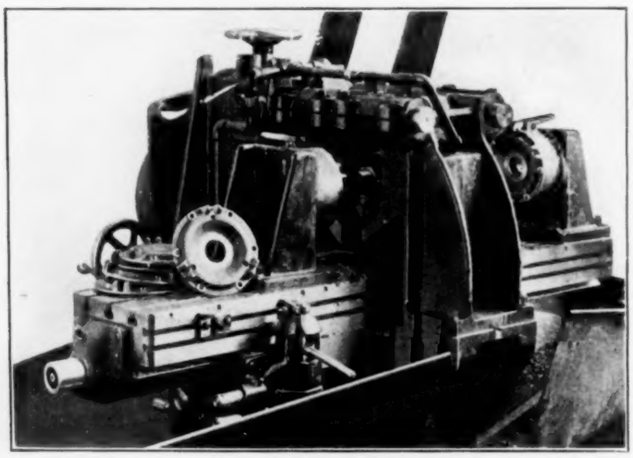

FIG. 2 A DEPARTURE FROM THE STEREOTYPED METHODS OF MILLING

It must be apparent that the recommendations of the sales engineer cannot be made on the spur of the moment, but must receive a reasonably thorough preliminary study and investigation. In the company with which the writer is connected it has been the practice for the last half-dozen years to make comparatively elaborate time studies, for which considerable advance information is needed. This information must not only cover the end which it is desired to accomplish, but should also include a reasonable amount of data as to the earlier and existing methods. This is particularly essential because it has developed that the sales engineer, seeking continual outlet for his machines, will often invade a field that has been considered the exclusive property of some other type of machine. It is sufficiently obvious that there must be much debatable ground to be fought over by the competitive representatives of the engine lathe, the turret lathe, and the automatic machine, and again between the planer, shaper, and miller. The ideal conclusions drawn from such investigations can only follow a very full consideration of all of the factors connected with production, and not only, as is sometimes the case, with the number of pieces turned out per machine per day. For these reasons certain standard forms are used, on which is entered the following information, derived from the user of the machine:

1 The quantity per annum and, if possible, the size of the lots in which the work is put through the factory
2 The degree of finish required
3 The quality of material
4 The depth of cut
5 The machine on which the work is now being done
6 The time consumed
7 The wage rate paid
8 The burden or overhead charge (particularly if departmental burden is available)
9 The objections, if any, other than as to the time consumed, that may be made to the existing method. This latter may deal with the labor supply, the dependence upon certain materials, etc.

This report is supplemented either by a sketch of the piece, or preferably by the cutomer's blueprints. Samples for preliminary cutting tests are also obtained whenever possible. With all of this information a time study can now be made up, which will give in full detail the separate operations, the time taken for each part of the operation, the speed and feed necessary, and a sketch and description of the fixture and cutters to be used. To the total time required for the production of the unit piece must be added a certain "overhead" percentage, which will, of course, vary, and is a figure that can be easily determined and established as a standard. This information is then submitted to the customer, and in certain cases accompanied by a cost sheet comparing the suggested and existing methods. This sheet will specify the time per piece, including the above percentage, the total time per annum for the quantity of pieces required, the wage cost, and the burden, or overhead cost, showing the annual saving over the existing system. Such cost-comparison and estimate sheets are in themselves not necessarily final, but their great virtue is that they form a nucleus for specific analysis and recommendations on the part of the customer and his engineers. It is particularly important that such detailed information should be submitted, because the production of a given machine is very often entirely independent on the ability of that machine to carry through a certain cut; it is often entirely dependent upon the chucking time necessary, and, still again, frequently dependent upon the spacing of the feed marks or quality of finish. This latter may very well be a commercial requirement and entirely independent of the degree of accuracy.

We can assume that the time study shows conclusively that the production is mainly dependent upon the operator's chucking capacity. There are two ways in which this may be increased: either by the elimination of certain functions which he must perform in connection with the machine, or by chang-

ing and improving the holding arrangements for the work so as to reduce the chucking time proper.

In a great many cases the first method is the most feasible, since it is only reasonable to suppose that the fixture or work-holding device, designed especially for the job, is less likely to be deficient than the machine, which has been designed for more general utility. It is here that the twofold influence of the sales engineer on both design and production becomes pronounced. It is here brought home to him very strongly that the specific limitation of his machine, while originally of small importance, is now preventing a greater output. It must then suggest itself to him that some mechanical means must be found for overcoming the hand operation of the machine, and either of his own volition or through the home engineering department he will produce modifications of the machine to suit requirements. This may not take place immediately, or for the specific customer through whom the need for this improvement arose, but it is very evident that the continued facing of the same problem must ultimately lead to its solution.

A further important point in this connection is the influence that will be brought to bear on this matter by the customer himself, who will generally clear his mind of all details of the machine and reach the pertinent points that are connected with production. He is quite apt to compare the machine with some other entirely different machine which incorporates some feature of marked importance to his particular class of work. It would seem, for instance, that the day of the automatic power-return of the tables of small milling machines would have come much sooner had their users compared the miller with the planer in the way that should have been done. It would really not have been necessary to compare the miller with the planer, but to have compared it even with some of the larger planer-type milling machines, on which such apparatus is standard equipment. It would further seem that the flooded lubrication of milling cutters should have come sooner had the proper comparisons been made between the milling machine and the grinder, and parallel cases could doubtless be found throughout the whole machine-tool field. The customer, as a rule, either has not the time, or perhaps lacks the energy to bring such points strongly enough to the attention of the manufacturer, and it is hoped that through the efforts of the sales engineer more concerted action between user and maker will accrue.

There is another phase of the sales engineer's influence on production, and that is concerned with work-holding methods or fixtures. There are in many shops ingenious methods in force for achieving a desired end, which methods may be very well adapted not only to the same specific job but to others of a similar nature. Now these methods must come fully under the eye of the sales engineer, not only in his visits to the customer's shop, but in his comparisons of suggested with existing methods. The interchange of ideas thus brought about will be more far-reaching in its influence than if the comparison between methods and production be always limited to one type of machine, since, as is well known, the different types of machines have each tended to develop a different system and standards of holding appliances.

The foregoing roughly outlines the direction in which the sales engineer may be expected to influence production and design, and many other details upon which his influence may be felt will doubtless present themselves.

The accompanying illustrations show the particular influence that has been exercised on one type of machine tool, the milling machine, by such work as has been described. It will be noted that some of the improvements have been effected in the fixtures themselves, but in many cases the design of the machine has been entirely changed to meet manufacturing conditions.

Fig. 1 shows a rather interesting equipment, designed for the milling of turbine buckets, these being made up from bar stock of the proper section. It is necessary to mill a groove in this bar for steam passage, this groove having a cam section when viewed both along the longitudinal and transverse axis. The obvious question that presents itself on seeing this photograph is, just where and why the milling machine? The answer to that question would really be that the sale of the milling machine was an adjunct to the furnishing of the special equipment, since the latter is more expensive and more complicated than the machine proper.

When in operation, the only part of the machine proper that is moving is the spindle, which rotates, carrying the cutter. All of the movements of the work itself are self-contained in the fixture, which has a combination axial and radial cam movement, controlled by master cams with a compressed-air resistance chamber, the table, feed, cross feed, etc., of the machine being used only for the preliminary adjustments. This equipment points absolutely to the need of a special frame to

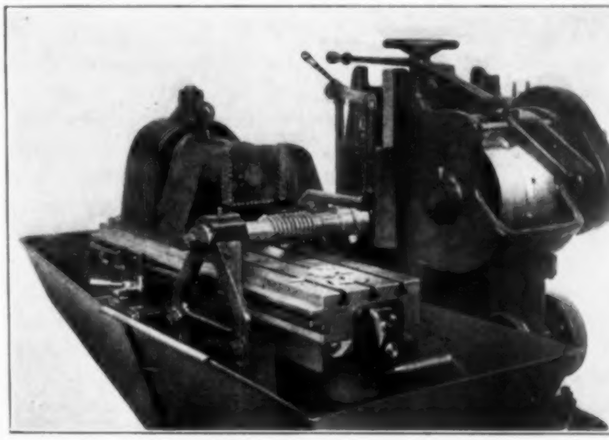

Fig. 3 One Operator and This Machine Produced More than Man and Boy with Standard Machine

take the place of the milling machine, which frame will contain a comparatively simple driving mechanism and a solid base, on which the fixture would have to be mounted. The cutter adjustments should all have been obtained through the vertical and axial raising of the spindle carrier, as in the Lincoln-pattern millers. Doubtless the succeeding machines that are installed for this purpose will be so made.

The second example, Fig. 2, shows a triple-spindle milling attachment fitted with an adaptation of the semi-automatic miller. Before this equipment was considered the work was handled in the stereotyped way, which consisted of one chucking, milling one set of bosses, indexing through 120 deg., milling the next set, indexing, milling the third set, and removing. With this equipment the three spindles mill all the surfaces at one passage, and the work itself is automatically clamped in place by means of the spring plunger shown in the center of the fixture. The table is provided with an automatic quick-forward movement, feeding movement, quick return to the fixture on the other side, and so on. The functions of the operator in this case are restricted to hooking the work onto the central locating stud and removing it when finished.

The example shown in Fig. 3 is interesting in that the conditions that had to be overcome before this equipment could

be installed were such as to make it hardly possible to effect a saving. The pieces that are milled with this apparatus are small tractor binder pins, having a half-round groove extending their full length, and which are slightly tapered on the outside. The old method for handling this work was to use a standard milling machine operated by a man who engaged the feed, returned the table and removed the work from the fixture. This man was aided by a boy, who drove the pins into the taper slots of a work holder while another holder was in the machine. The machine under such conditions was cutting most of the time, and the boy was loading the pieces into the work holder as rapidly as they are loaded today; but with the arrangement shown in Fig. 3 the production was considerably increased, and that with one operator only. The fixture is designed so that it automatically indexes, and the forward movement of the work to the cutter is taken at a high table traverse. The pins do not have to be driven firmly into the slots, since the action of the cutter itself tends to force them home to a bearing. They do not have to be removed from the fixture after the milling operation is completed, because the third stop in the indexing brings the finished pieces against a fixed ejector bracket which pushes them out of the holes. The operator loads into the upper horizontal slots, and he can also load in slots of the front vertical face should he fall a little short in his chucking of the full number held in the one side. It will be seen that with the exception of the twentieth part of a minute taken for indexing from one surface to another and a similar twentieth taken in returning we have cutters which operate all the time. There is no dwell and the operator's cycle is of the very simplest character possible. His functions are confined to putting the work loosely into the holder. He does not have to move it after cutting, and the only thing open for improvement in this connection would be the provision of a hopper feed, so that a bucketful of the pins could be thrown in indiscriminately, and the machine then become entirely automatic. This is the next step which will doubtless follow.

The foregoing illustrations are not intended as examples of perfected coördination between the customer and manufacturer. Some of them indeed are rather intended to show how far we have fallen short of the ideal, while still complying with existing commercial conditions. The purpose that they do fulfill, however, is to show that an attempt has been made to depart from standard practice where the need for such action was indicated by a study of the conditions. The resulting equipment, while not ideal from a designer's standpoint, in that it was obviously necessary to start with a foundation laid down for more general purposes, does nevertheless perform satisfactorily, and so justifies itself from the viewpoint of dollars and cents. More important than this, however, is the clearer light thrown upon the problem, the positive indication of the direction of future design, and the certainty that the combined knowledge of all concerned has been so utilized as to make it valuable for future research.

In many hydroelectric plants there is for some months of the year an excess of energy which is, to a large extent, not utilized. Use has been made of this excess by a Swiss company, for raising steam in the boilers of a reserve plant. Electric heating elements are placed on the grate bars of the furnaces, from which they are readily removable when it is desired to fire with coal. The three boilers of the company's Zurich station furnish 12,390 lb. of steam per day, with a consumption of 7392 kilowatt-hours, thus saving about 1650 lb. of coal.

The grain size in a metal may be measured by a method described by Z. Jeffries in a paper read recently before the Faraday Society. The method consists in counting the grains completely and partly included in the circular part of an image at standard magnification of the specimen; and by means of an empirical formula finding the number of whole grains in the area. The president, commenting on the method, mentioned that a 0.58 carbon steel contained 5540 grains per sq. in. when forged, and if forged and annealed, 4500. When the steel was water-quenched and reheated, the number rose to 330,000.

At a recent meeting of the British Association, in the section of mathematical and physical science, Dr. P. E. Shaw, of Nottingham University College, gave a brief account of the remarkable experiments which he has been conducting for several years in a vault of the Physics Department of the college with a Cavendish balance for the purpose of determining a possible temperature coefficient of gravitation. Such experiments require the most extraordinary care. For example, the readings of temperature are taken through an optical window by means of a telescope. One has to guard against electrostatic effects, magnetic effects, radiometric pressure, radiation pressure, convection, damping, stiffness and torsion of the wires, etc. An enormous amount of the work remains still to be done, notwithstanding the very large amount done already.

The average automobile brake is insufficiently powerful, requires too much effort to apply it, and requires too constant adjustment; its surfaces need too frequent renewal; it is harsh in action, affected by oil and dirt, and a prolific creator of rattles and squeaks. Any good engineer could design better brakes if he would only take the trouble, but it is quite usual to find that a man who will spend months calculating the stresses in almost every other part of his car will accept any sort of brakes without a thought. This is not confined to any one country; it is true of every place where motor cars are made, though least true of Italy, because Italian factories being all at the foot of the Alps, the need for exceptional brakes is forced upon the designers. Still, even the brakes of Italian cars are not always ideal, as the requisite power is often obtained at the expense of harshness.

In a letter recently addressed by the Aeronautical Society of America to the Secretaries of the Army and Navy, the Society, after careful consideration of the needs of this country in the matter of aerial defense, comes to the conclusion that from 8,000 to 10,000 heavier-than-air machines of various types are required. It arrives at the conclusion that our bill for effective defense of the country against foreign invasion in so far as it affects the most important branch of this defense, aviation, is as follows, depending upon whether a program of 8,000 to 10,000 ships is adopted:

Fighting and scout planes....	$120,000,000	to	$150,000,000
Dirigibles	30,000,000	to	40,000,000
Ships, etc., for planes.........	16,000,000	to	20,000,000
Ships, etc., for dirigibles......	2,000,000		
Mother ships.................	6,000,000		
Training schools..............	40,000,000		
Total	$214,000,000	to	$250,000,000

ANNUAL MEETING PAPERS

Comprehensive Abstracts of Fourteen of the Papers to be Presented and Discussed at the Thirty-Seventh Annual Meeting of the Society, New York, December 5 to 8, 1916

THERE are printed below, and there will be concluded in the December issue of The Journal, comprehensive abstracts of the papers to be presented and discussed at the forthcoming thirty-seventh Annual Meeting of The American Society of Mechanical Engineers, to be held in the Engineering Societies Building, New York City, December 5 to 8, 1916.

These abridgements have been prepared with the collaboration of authors, and are therefore authoritative presentations of the subject-matter of the papers. In many cases the abstract comprises practically the entire paper, with the omission of only such sections as mathematical derivation of formulæ, minute descriptions of apparatus, and logs of tests.

Engineers—members of the Society and others—are invited to contribute discussion to these papers. Such discussion will be read at the meeting and be published in The Journal.

All the papers printed below are also being printed in unabridged form in pamphlet size, and members of the Society desiring a pamphlet copy of any particular paper may obtain it gratis upon application to the Secretary.

THE UTILIZATION OF WASTE HEAT FOR STEAM-GENERATING PURPOSES

By ARTHUR D. PRATT,[1] NEW YORK, N. Y.

Non-Member

The utilization of waste heat from various industrial processes for the generation of steam is not new. The advance within the last few years, however, in methods of utilizing such gases and in the results secured from their utilization has been so remarkable as to make of interest a comparison of former with present-day methods and results.

The design of waste-heat boilers has progressed to a point where it is today possible to successfully generate steam from gases whose temperatures[2] are as low as 950 to 1000 deg. fahr. It is but a few years since it was considered absolutely impracticable from a commercial standpoint to attempt to produce power from such gases, and it is in its ability to satisfactorily utilize these gases that the development of the modern waste-heat boiler has its most far-reaching effect.

The sole theory on which early waste-heat boiler installations were made has as its basis the non-interferences in the operation of the primary furnace. This meant, in practically all cases, that the draft at the exit of the primary furnace should in no way be impeded, and resulted in the installation of a given amount of heating surface arranged in such manner that the frictional resistance to the gases in their passage through the boiler should be a minimum. Presumably the object of such an arrangement was to enable a natural-draft stack of a practicable height to be used. As the result of minimizing this draft loss, such boilers as were installed were ordinarily entirely without baffles and the gases were given a straight passage through the boiler, though partially baffled boilers were used occasionally. High exit-gas temperatures were considered rather desirable than otherwise in order to assist the stack in giving the required drafts.

Boilers installed in this way were considered practicable only with gases whose temperatures approached those of coal-fired practice. The users accepted the steam generated as "something for nothing" and no particular endeavor was apparently made toward increased capacities.

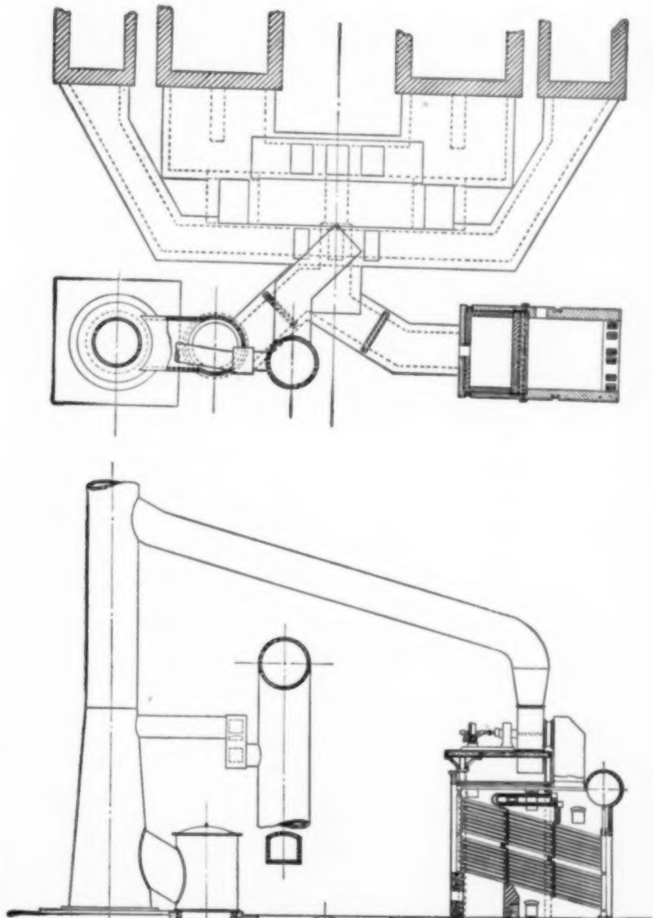

FIG. 1 WASTE-HEAT BOILER FOR OPEN-HEARTH FURNACE

Present-day waste-heat practice has come about with a more thorough understanding of the laws governing heat transfer and an appreciation of the function of gas velocity as affecting transfer rates. Without going into this aspect, it may be broadly stated that the rate of heat transfer is dependent upon

[1] Assistant to Advisory Engineer, The Babcock & Wilcox Co.

[2] All temperatures herein given are in deg. fahr.

For presentation at the Annual Meeting of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, New York, December 5 to 8, 1916. The paper is here printed in abstract form, and advance copies of the complete paper may be obtained gratis upon application. All papers are subject to revision

gas velocity and temperature difference between the gas and the absorbing surface. Experiments have shown that at even the highest velocities now used in waste-heat work the effect of increased temperature difference is small as compared with that of increased gas velocity.

In coal-fired boiler practice, the average temperature difference between gases and boiler surfaces is approximately 1150 deg. The heat-transfer rate corresponding to a boiler's rated capacity is about 3 B.t.u. per hr. per sq. ft. of surface per degree difference, or a heat absorption of 3450 B.t.u. per sq. ft. of surface per hour. In waste-heat work the temperature difference varies widely with the class of waste heat. With a gas temperature of say 1250 deg. entering a boiler, the average temperature difference between boiler surface and gas for a working pressure of 170 lb. per sq. in. will be about 500 deg. For such a temperature difference the transfer rate to give an absorption per square foot of surface equal to that of the coal-fired boiler at rating, would have to be 6.9 B.t.u. per hr. per sq. ft. per degree difference. This rate is slightly higher than the rates corresponding to velocities that are as yet ordinarily used, but, with somewhat higher entering-gas temperatures, the absorption per square foot of surface is such as to enable a boiler's rated capacity to be developed without difficulty. With gas temperatures entering the boiler of 1800 to 2000 deg., which approach coal-fired practice, high overloads are being developed.

TABLE 1 RESULTS OF TESTS OF WASTE-HEAT BOILERS FOR OPEN-HEARTH FURNACES

Test Number	1[1]	2	3	4
Plant	Illinois Steel Co.	Indiana Steel Co.	Bethlehem Steel Co.	Lackawanna Steel Co.
Location	S. Chicago, Ill.	Gary, Ind.	S. Bethlehem, Pa.	Buffalo, N. Y.
Rated capacity of furnace, tons	65	75	80	[5]
Actual production, tons	72[2]	85	82.6	......
Boiler	Stirling	Rust	B. & W.	B. & W.
Heating surface, sq. ft.	4,000	4,880	5,232	5,407
Superheat, deg. fahr	128	176	121	97
Gas weight, lb. per hour	73,000	83,434	75,271	78,947
Gas per hr. per sq. ft. htg. surf.	18.3	17.1	14.4	14.6
Temperatures:				
Gas entering boiler, deg. fahr.	1227	1155	1362	986
Gas leaving boiler, deg. fahr.	621	530	493	468
Drop in temp., deg. fahr	606	625	869	518
Draft at boiler inlet, in	......	1.47	1.55	1.76
Draft at boiler damper, in	......	3.95	3.29	3.63
Draft loss, in	1.78	2.48	1.74	1.87
Gross h. p. developed	334.5	393	425.8	306
Per cent of rated capacity[6]	83.6	80.6	81.4	56.7
Boiler h. p. to fan	[3]	60[4]	24.3[3]	......
Net horsepower	......	386	401.5	......
Approx. transfer rate (R)	5.08	6.92	4.77	5.12

[1] Average of ten tests. [2] Approximate. [3] Motor-driven fan. [4] 53 h.p. returned in feed-water heater. [5] Tilting furnace. [6] All ratings on basis of 10 sq. ft. per h.p.

The gas velocities necessary to give what is now considered a desirable transfer rate lead to a frictional resistance through waste-heat boilers which makes the use of a natural-draft stack impracticable. Let us consider what is probably the extreme case insofar as draft conditions are concerned, namely, the open-hearth steel furnace. Common practice in this class of work is to use stacks 160 ft. high, which give a draft at their base of approximately 1.4 to 1.6 in., depending upon the gas temperatures. For the present purpose, assume that the draft loss through a modern waste-heat boiler installed with an open-hearth furnace is 2.0 in., a figure which approximately represents the practice of today. With a natural-draft stack, the draft at the checkers corresponding to the 1.4 to 1.6 in. given above is approximately 1.3 to 1.5 in., and this amount is necessary for the proper operation of the furnace. With a waste-heat boiler installed, then, the draft necessary at the exit of the boiler must be sufficient to overcome the resistance through the boiler, 2 in., that necessary to overcome resistance through the flues, say 0.75 in., and 1.5 in. necessary at the checkers, or a total of 4.25 in. It is to be remembered that with a waste-heat boiler installed, the temperature of the gases entering the stack, instead of being 1000 or 1200 deg., will be 450 or 500 deg., under which conditions a stack of 160 ft. instead of giving a draft of 1.4 to 1.8 in. at its base would give approximately 0.9 in., and to give the necessary 4.25 in. the stack height would have to be somewhat over 700 ft.

While, as stated, this is perhaps the extreme case, the same reasoning applies in practically all waste-heat work, and an induced-draft unit is now almost universally used with the modern design of waste-heat boiler. In certain classes of waste-heat work, such a fan not only furnishes the required draft suction, but is of a decided advantage in the operation of the primary furnace. This feature is discussed in the paper.

As may be inferred from the foregoing, the successful utilization of waste gases becomes more difficult with decreasing gas temperatures. It was in connection with regenerative furnaces and low-temperature gases that the principles of high gas velocity were first applied and the modern waste-heat boiler was developed. The success of the early installations in this particular class of work led to the application of this theory to all classes of waste-heat practice.

Waste-heat boilers of the modern design are in successful operation today with copper refining furnaces, cement kilns, open-hearth steel furnaces, beehive coke ovens, zinc refining furnaces and heating furnaces of various types, both regenerative and non-regenerative.

As stated, the waste-heat boiler of today was developed with low-temperature gases, and its largest field, until the present, has been with open-hearth steel furnaces. For this reason this class of waste-heat work is considered first. The following is an abstract of this consideration, and of the sections of the paper devoted respectively to cement kilns, copper furnaces, beehive coke ovens, heating furnaces and miscellaneous, including zinc furnaces, nickel refining furnaces, gas benches and oil stills.

OPEN-HEARTH STEEL FURNACES

Under this heading the paper describes in detail certain features of installation and operation, some of which refer specifically to open-hearth work and others to waste-heat work in general. These include location of boilers, connecting flues, air leakage, cleaning, dampers and explosions.

"The application of waste-heat work to open-hearth steel furnaces may be considered new. In this type of furnace we have the best and by far the most numerous examples of the regenerative furnace. From the very nature of the operation of such furnaces, gas temperatures passing to the stack are low, and the ability of the modern waste-heat boiler to utilize successfully these gases for the generation of steam is, without question, the best proof of the progress in the development of this particular class of boiler."

Four installations of waste-heat boilers for open-hearth furnaces are described—one of two Stirling boilers at the plant of the Illinois Steel Co., one of 28 Rust boilers at the Indiana Steel Co., one of Babcock and Wilcox boilers at the Bethlehem

Steel Co., and one of Babcock and Wilcox boilers at the Lackawanna Steel Co. Results of tests of these installations are compared in Table 1.

A typical successful layout of waste-heat boilers for this class of work is illustrated in Fig. 1. Approximate figures showing the great savings made possible by the installation of waste-heat boilers with open-hearth furnaces are included in the paper.

CEMENT KILNS

"The use of waste-heat boilers in the cement industry is not, strictly speaking, new. The number of installations, however, has been extremely small, and there appear to have been several reasons for the non-development of such boilers in this field."

Reference is made to several installations of waste-heat boilers with cement kilns, the first of which are typical of early waste-heat practice while the last is representative of the modern design of this class of boilers. Results of tests of these installations are given, from which the advantages of the modern waste-heat design are shown.

Factors of draft, cleaning and leakage are discussed in detail, and the possibilities of savings through the use of waste-heat boilers in this work are pointed out.

COPPER FURNACES

"The copper furnaces with which waste-heat boilers have been installed may be classed under two general heads: smelting furnaces (matte furnaces) and refining furnaces. Both classes are fundamentally the same in design, though for metallurgical reasons dimensions of the two classes and individual furnaces in the two classes are varied considerably."

Experiences of the Anaconda Copper Mining Company with Stirling boilers, of the Cananea Copper Co. with Stirling and Aultman and Taylor boilers installed with copper smelting furnaces are described, and also those of the Baltimore Smelting and Refining Co. with Stirling boilers utilizing the waste heat from copper refining furnaces. Other refining companies followed the Baltimore Co. in this practice, and the author is familiar with over 11,000 h.p. of boilers with refining furnaces alone.

As in the foregoing sections, results of tests are tabulated.

BEEHIVE COKE OVENS

"This class of waste heat is considered because of the very remarkable results being secured from modern waste-heat boilers utilizing gases from beehive ovens, and because of the possibilities of saving, due to this utilization, until such time as beehive ovens are replaced (with by-product ovens). Furthermore, there are available figures (given in the paper) from boiler installations made a number of years ago for this class of work, and from a comparison with the results today the great advance in the design of waste-heat boilers may be readily seen."

Even granting that beehive ovens will ultimately be replaced with by-product ovens, the author considers that, in numerous plants, an installation of waste-heat boilers would pay for itself many times before such a change could be made, and that it would be entirely possible, too, in these installations to design the boilers in such a manner that at the time of replacing the beehive ovens the boilers could be dismantled and reset either for burning coal or coke breeze, or to be fired with by-product coke-oven gas.

HEATING FURNACES

The early history of waste-heat boilers applied to heating furnaces is in reality the early history of the utilization of waste heat in general.

The early designs of boilers in most general use in this class of work are described and illustrated, this being followed with a description of the first waste-heat boilers of the strictly modern design and utilizing the theory of high gas velocity, these boilers being installed by the Bethlehem Steel Co. Results of three tests on this latter installation are tabulated.

MISCELLANEOUS

"While by far the greatest number of waste-heat boilers in service are in the industries outlined above, there are numerous installations in plants of different character."

In this miscellaneous class, while the number of installations in any single industry is small, reference is made to certain of these to give an idea of the wide and varied field for development in the use of waste heat.

THE TESTING OF HOUSE-HEATING BOILERS

By L. P. BRECKENRIDGE and D. B. PRENTICE,
NEW HAVEN, CONN.
Members of the Society

THIS paper discusses a standard method for testing house-heating boilers, which so far have not received the attention of the Power Test Committee of the Society. If all boilers are classified as either power or heating boilers, we define a house-heating boiler as one of the latter group designed to serve 2000 ft. of radiation or less. This is equivalent to a boiler of less than 14.5 h.p. Such a boiler is usually operated with little attention, infrequent firings, low rate of combustion, and automatic pressure regulation by damper control.

The satisfactory testing of house-heating boilers by a method which admits of fair comparison is important for three reasons:

a On account of the increasing cost of anthracite coal it is desirable to determine efficient types of heaters and the most efficient method of burning this fuel

b It is desirable to develop efficient types of furnaces for other fuels, such as bituminous coal and coke

c By means of standard tests it is desirable to establish a satisfactory rating system which will eliminate the uncertainty of the present manufacturers' ratings of house-heating boilers.

REQUIREMENTS IN TESTING HOUSE-HEATING BOILERS

The authors believe that a method of testing any apparatus to give results of value should meet two requirements:

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a The apparatus should be tested with as many conditions as possible equivalent to those under which it normally operates (except for particular investigations under special conditions)

b Errors should be so far eliminated or reduced that results can be reproduced.

To meet the first requirement with a house-heating boiler it is necessary to operate at a moderate, reasonable pressure, controlled automatically, as would be the condition in an actual installation. It is proper to fire the fuel in rather heavy charges and to give attention to the boiler only at intervals of several hours. The fire should not be frequently shaken or poked. The temperature of the feed water should be comparable to the returns from a radiator system, and the boiler should be supplied with water continuously and uniformly. Perhaps the greatest essential is that the test should be started

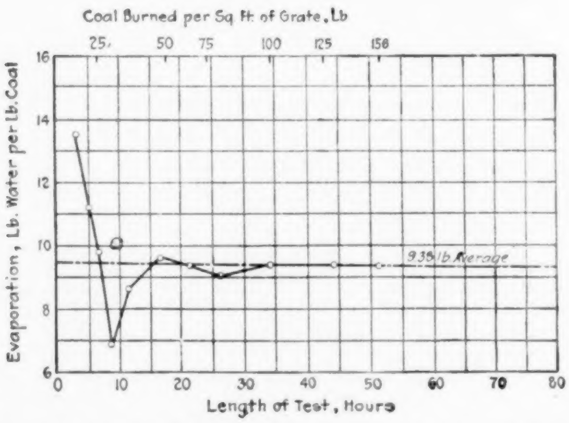

FIG. 1 SPECIAL TEST TO DETERMINE PROPER LENGTH OF HEATING-BOILER TESTS

under average running conditions, with the boiler and covering thoroughly heated to bring the radiation loss to equilibrium, and with a fire neither freshly kindled on bare grates nor clogged with ash; in brief, a good, thin, recently cleaned fire.

The elimination or modification of errors so that results can be verified by several tests presents some difficulties. The measurement of coal fired in the boiler is a matter of careful weighing. Determining how much coal has been burned is necessarily somewhat uncertain. The method of starting and stopping described later, the authors believe, decreases the error of measurement, yet makes the test under normal running conditions. The low rate of combustion in house boilers and the small amounts of fuel involved make long tests essential. It is necessary to burn at least 40 lb. of coal per sq. ft. of grate area, or to test for at least 12 hours, to secure results that can be approximately duplicated. The error in coal measurement is then distributed over an amount large enough to make it a small percentage of the total. That shorter tests are unreliable is shown by the diagrams of two special tests, Figs. 1 and 2. In these tests, from the start to any one of these endings may be considered a complete test. The evaporation per pound of coal has been calculated for the several periods from the start to the successive closing points, and these performance values are plotted against the elapsed time, that is, the durations of the corresponding periods. The heavy horizontal line represents the average evaporation for the longest period. The vertical distance of any point from this line is the error in the calculated rate of evaporation which would result from closing the test at that time. Very little gain in accuracy is secured by long tests.

CONTROL OF BOILER OUTPUT

The output of a boiler during a test may be controlled in one of several ways or it may be allowed to vary. The latter condition reproduces, strictly, house operation, where the heating load is uneven, depending on wind and weather. But testing on such a plan would be very unsatisfactory; for the duplication of a test would be a matter of chance, and innumerable experiments might be necessary to produce a performance curve for a fair range of output. Some control is desirable, preferably by a constant and accurate method. Condensation in radiators or piping, the amount of surface that is open to steam being regulated, is too variable. An orifice of some kind is a better control. However, the pressure in the boiler is not even, and the discharge of steam directly through a certain opening would not be uniform. An excellent arrangement seems to be to maintain a pressure of 2 lb. per sq. in. in a receiver by an automatic pressure-reducing valve, the boiler carrying 3 to 8 lb. The discharge from the receiver through a given area is then constant. The authors believe that a tapering needle valve is more satisfactory than a set of changeable orifices, as it facilitates varying the load during operation. A bank of valves of varying size, opening from the receiver, is another convenient and suitable method of control. The exhaust steam may be used to warm the feed water or it may be condensed and used again.

The method of feeding the water to the boiler is not important provided a steady, easily controlled flow is secured. The

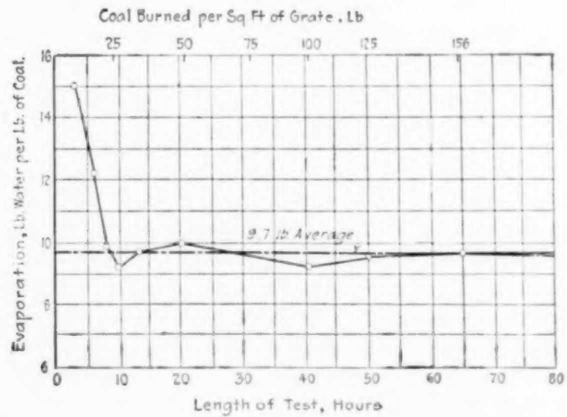

FIG. 2 SPECIAL TEST TO DETERMINE PROPER LENGTH OF HEATING-BOILER TESTS

measurement of boiler output may be made either before or after the water goes to the boiler. An extremely convenient method is to draw the water supply from a tank fitted with a long gage glass and scale. The level is quickly noted and no "weighing back" is necessary. The tank should be carefully calibrated, by weighing, over the entire range between the extreme levels reached. A duplex water-driven pump is a very convenient device for feeding the boiler wherever city water pressure is available.

METHOD OF STARTING TESTS OF HOUSE-HEATING BOILERS

The authors have found the following method for starting house-heating boiler tests very satisfactory. A preliminary fire is carried until the boiler is well heated and operating at the usual pressure, about 5 lb., and the load at which the test is to be made. When conditions are considered stable, the preliminary fire is allowed to burn down, the pressure begins

to fall, and the fire is shaken, which retards the pressure drop temporarily; but soon a pronounced fall is noticed. The fire is now thin, clean, burned-out, but still hot enough to kindle fresh fuel. When the pressure reaches a given point, perhaps 3 lb., the necessary measurements are made, including a careful determination of the thickness of the fuel bed, the first charge of weighed coal is fired, and the test is considered started. When the test is drawing to a close these same conditions are readily duplicated, and at a point, after shaking, when the pressure falls to 3 lb., the test is concluded. The ash should be shaken out until the thickness of the fuel bed is the same as at the start. The events outlined are characteristic, and a recording pressure gage pictures them very clearly. The accompanying diagram, Fig. 3, was copied from a pressure chart made during an actual test. The periods of falling pressure immediately before the beginning and ending of the test, as well as before each firing, are quite distinct.

PROPOSED UNIT OF CAPACITY FOR RADIATORS AND HEATING BOILERS

The capacity or commercial rating of a heating boiler has always been given in terms of the direct radiating surface which it would serve. The unit usually employed is the "foot of radiation," commonly understood to be that surface which will condense a quarter of a pound of steam per hour at 2 lb. pressure when in still air at 70 deg. fahr. Originally the foot of radiation meant a square foot of radiating surface, but improvements in design and arrangement enabled manufacturers to secure this condensation with less surface, and consequently less weight of iron. The result has been a variable and decreasing value in square inches for the "foot of radiation." In fact, the unit has become, as it should, dependent entirely on condensation of steam, which means a heat transfer, rather than on any particular area of metal.

If the unit is considered as a certain number of heat units it is applicable to boilers directly, as well as to radiation. There are many reasons why it would be convenient to have a capacity unit for heating boilers comparable to the capacity unit for power boilers, *i.e.*, the boiler horsepower. The authors propose, therefore, the following definition of a unit for stating the capacity of radiators and heating boilers:

The "foot of radiation" shall be a quarter of a pound of steam condensed from and at 212 deg. fahr. per hour.

This is equivalent to a heat transfer of 242.6 B.t.u. The condensation of a quarter of a pound of steam at 2 lb. pressure is equivalent to 241.5 B.t.u. There is, therefore, very little change in the heat equivalent of the unit. Although there is no direct connection between the unit as defined above and a square foot or any particular area of radiating surface, yet the authors favor the retention of the old name for the same reason that boiler horsepower was continued, although that unit bears no relation to the standard horsepower.

The advantages of the above definition of the "foot of radiation" are:

a The heating- and power-boiler capacity units are based on the same physical conditions.

b They are mutually convertible by the factor 138.

c Radiation is rated without reference to surface, so that efficient designs and arrangements are benefited.

d The unit is applicable to hot-water radiators and heaters by determining the heat transfer. (The result may be called "equivalent feet of radiation").

The authors recommend that radiator tests to determine rating be made with steam at 2 lb. pressure and in "still air" at 70 deg. fahr., and suggest that boilers under test be operated at from 3 to 8 lb. pressure.

PROPOSED HOUSE-HEATING BOILER CODE

[The paper proceeds to give the proposed individual code for house-heating boilers to be used in conjunction with the First Section (General Matters) of the Report of the Power Test Committee of the American Society of Mechanical Engineers. This code follows closely the A.S.M.E. boiler code of 1915, differing materially only in the paragraphs dealing with the

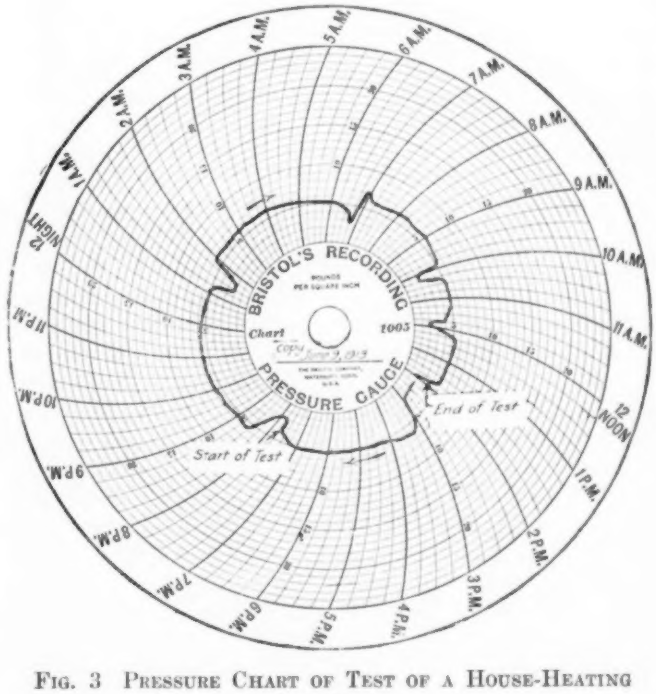

Fig. 3 Pressure Chart of Test of a House-Heating Boiler

duration of tests, the method of starting and stopping tests, and the calculation of results. These paragraphs are given below.]

DURATION

The duration of tests to determine the efficiency of a house-heating boiler should be at least 12 hours of continuous running, or such time as may be required to burn a total of 40 lb. of fuel per square foot of grate. The duration of tests which include periods of banked fires should not be less than 24 hours. The duration of tests to determine the maximum evaporative capacity of a boiler without determining the efficiency should not be less than 3 hours.

STARTING AND STOPPING

The conditions regarding the temperature of the furnace and boiler, the quantity and quality of the live fuel and ash on the grates, the water level, and the steam pressure, should be as nearly as possible the same at the end as at the beginning of the test.

To secure the desired equality of conditions the following method should be employed:

The furnace should be well heated by a preliminary run of at least an hour under all the conditions at which it is proposed to test. A suitable pressure for running the boiler while under test is from 5 to 8 lb. During this run the operation of the pressure-reducing valve and damper control should be tested, and the setting of the output-control valve should be verified. The fire should now be allowed to burn low, which will result in a falling pressure. When the pressure reaches a chosen point (3 lb. is recommended), the fire should be shaken clear of ash, the thickness of fuel bed noted, the water levels in boiler and feed tank recorded, together with steam pressure, draft, flue temperature and the other usual data. The first charge of weighed fuel should now be fired and the time recorded as the starting time for the test. The test should be ended when the fire has burned low and it is impossible to check the pressure fall by shaking, as at the start. When the pressure again reaches the chosen point the final readings should be made, the ash shaken out until the fire is the same thickness as at the start, and the time recorded as the stopping time. It is advisable to regulate the feed so that the water in the boiler is brought to the starting level and held there, toward the end of the test. All ash should be removed from the ashpit immediately after the fire is shaken down at the beginning of the test and again at the end. The second lot, with any that may have been drawn during the test, should be carefully weighed.

CALCULATION OF RESULTS

The method to be followed in expressing and calculating those results which are not self-evident or stated in detail in the Boiler Code, is as follows:

The capacity of the boiler in " feet of radiation " served is found by dividing by 242.6 the total heat absorbed per hour by the water in the boiler, expressed in British thermal units.

THE PROPORTIONING OF SURFACE CONDENSERS

By GEORGE A. ORROK, NEW YORK, N. Y.

Member of the Society

DURING the discussion of my paper on The Transmission of Heat in Surface Condensation,[1] I was asked to present formulæ covering the application of the results of my experiments to the design of surface-condensing apparatus. Since the appearance of the paper there have been a number of papers on allied subjects whose authors have approached the subject from a somewhat different standpoint, and the conclusions presented have been of varying character and usefulness in the design of surface-condensing apparatus. Only one author, Loeb,[2] has presented new experimental data which can be used for checking the heat-transfer constants, but considerable mathematical work has been done along the line of following out Jordan's deductions from Osborne-Reynolds's statement of the law of heat transfer.

I propose in this paper to discuss the state of the art of " heat transfer in surface condensation," and to establish design formulæ for use in proportioning condensing apparatus.

THE PROBABLE LAW OF TEMPERATURE RISE

The law of temperature rise of the water in a condenser tube is still unknown. My own tests led me to believe that this law departed somewhat from the logarithmic law as stated by Smith and Josse, but their results are sufficiently variant to allow for a slight modification. Loeb, however, has presented a set of tests with plotted curves, from which he deduces that the law is of the exponential form, with approximately 0.9 as the exponent. My plotting of his numbers places the exponent nearer 0.8, both of which are not far from my adopted figure of 0.875. These variations are not of prime importance for practical design, and indeed may be caused by the apparatus used in the making of the experiments; and I am still of the opinion that we may use $N = K\theta^{0.875}$ as the basis of our work, N being the total heat transfer per sq. ft. per hour in B.t.u., θ the temperature difference, and K a constant determined by experiment.

VISCOSITY NOT AN IMPORTANT FACTOR IN DESIGN

It has been stated in London Engineering (Jan., 1914) that the extreme variation in the results of heat-transfer experiments has been caused by a neglect of the variation due to the viscosity of the water, and quite an extended argument was given to show that some of these experiments were reconciled when the correction was applied. Wilson has carried this method to its logical conclusion in his paper, A Basis for Rational Design of Heat-Transfer Apparatus,[1] lately presented to the Society. Our work in the design of surface condensers, however, is mainly concerned with a very small variation in temperature, the upper limit of which is fixed by the vacuum carried at somewhere between 80 and 90 deg. fahr., while the lower limit in America is between 65 and 70 deg., and in Europe perhaps a few degrees lower—in all a variation of perhaps 20 deg. In the winter we can carry good vacuums with low heat transfer and our troubles are few, but the problem is the summer problem, and here the difference in viscosity is small. As a matter of fact, I believe Osborne-Reynolds's straight-line law does not apply where there is a change of state at either side of the metallic surface. Observers making use of this hypothesis have been frequently misled by the bunching of the results in the condenser range, with the consequent spreading of the results outside this range. This may be seen in Fig. 8 of Wilson's paper.

CRITICAL VELOCITIES NEED NOT BE CONSIDERED

There has been considerable comment on the effect of stream flow and turbulent flow on the heat transmission, and as there is a marked change in the friction characteristics between the two states of flow, the conclusion has been drawn that there will be a similar effect on the heat-transmission characteristics. Osborne-Reynolds investigated this subject and gave formulæ for the critical velocities. He finds two critical velocities, the lower, which we may call V_c, below which all motion is stream-line and if disturbed artificially will return to stream-line flow; and an upper critical velocity, V_s, above which all motion is turbulent. Between the two is a field in which stream-line motion may be maintained if no artificial causes upset it, or turbulency may be set up and will maintain itself when so started. He gives formulæ for these two velocities, which, following Parker, are

$$V_c = \frac{0.0388\,P}{D} \text{ and } V_s = \frac{0.2458\,P}{D}$$

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[1] Trans. Am.Soc.M.E., vol. 32, p. 1139.

[2] Jour. Am. Soc. Nav. Eng., May, 1915.

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[1] Trans. Am.Soc.M.E., vol. 37, p. 47.

where D is the internal diameter of the tube in feet and P is Poisseuille's ratio, *i.e.*, the ratio between the viscosity and density of the water. If the values of v = viscosity and δ = density be taken in C.G.S. units,

$$P = 56.2\,\frac{v}{\delta}\left\{\begin{array}{l} = 1.000 \text{ at } 0 \text{ deg. cent. (32 deg. fahr.)} \\ = 0.734 \text{ at } 10 \text{ deg. cent. (50 deg. fahr.)} \\ = 0.455 \text{ at } 30 \text{ deg. cent. (86 deg. fahr.)} \end{array}\right.$$

This agrees with Osborne-Reynolds's value, which is

$$P = \frac{1}{1 + 0.0336\,T + 0.000221\,T^2}$$

where T is the temperature in centigrade degrees (not the absolute temperature, as stated in Wilson's paper). The table of correction factors in Wilson's paper may be used as a table of P by multiplying the correction factors by 0.625, thus correcting the values to 32 deg. fahr. The critical velocities for a 1-in. No. 18 B. W. G. condenser tube will then be as follows, T being the mean temperature of the water:

T deg. fahr.	40	50	60	70	80	90	100	115	130	150
V_c....	0.50	0.422	0.362	0.318	0.278	0.25	0.224	0.192	0.166	0.14
V_a...	2.84	2.400	2.060	1.810	1.580	1.42	1.270	1.000	0.945	0.80

In condenser practice and in most of the apparatus for heat-transfer experiments it is nearly certain that the flow is turbulent above V_c. Velocities from 6 to 10 ft. per sec. are the common range in modern surface condensers, so that in every practical case the critical velocity need not be considered.

CONDITIONS DETERMINING THE VALUE OF THE COEFFICIENT K

Surface-condensing apparatus is never tested to the capacity of the surface to transfer heat, and Gibson and Bancel[1] have shown this in their characterizing the "active" and "inactive" zones in a surface condenser. The condenser must be designed for the maximum load that may be put on it when the entering water is at its maximum temperature, and additional surface must be installed as a factor of safety against dirty, oxidized tubes and the presence of undue amounts of air. The depression of the hot-well temperature below the vacuum temperature, a well-marked phenomenon in many condensers, may be eliminated by good design, and many tests by careful investigators have been reported in which the depression was zero. Certain designs of the dry-tube type may give hot-well temperatures somewhat higher than the average temperature in the condenser. The hot-well depression is especially marked where drowned lower tubes are used.

Neilson and others have objected to conclusion (b) in my 1910 paper[2] that the heat transmission is approximately proportional to the square root of the cooling-water velocity. Within the condenser range the experiments may perhaps be better represented by $KV_w^{0.6}$ instead of $KV_w^{0.5}$. Weir (Trans. I.E.S.S.), in his paper read Oct. 22, 1912, gives a curve for the relation of U to V_w for design purposes. The curve corresponds very closely to $U = 250\ V_w^{0.6}$, the maximum variation being less than 2 per cent. It is possible that a closer agreement might be secured by using more figures in the exponent, but such a procedure is hardly necessary, as probably we have already exceeded the accuracy of our experimental apparatus. The effect of air in reducing heat transmission has been shown in my 1912 paper,[1] and a term introducing the second power of the pressure ratios recommended to allow for it in design. This subject is still unsettled and will remain so until Smith's experiments are repeated on a proper scale, with known amounts of air present in the condenser. We may say that the term $(P_s/P_t)^2$ represents the reduction of heat transmission by air, with a possible variation of 10 per cent. The difficulty is in obtaining a figure for the amount of air present and its temperature. The use of the air bell enables the operating man to keep his leakage down to the minimum, and where water-jet air pumps are used the addition of the testing dry vacuum pump and air bell will usually pay for themselves in a very short time.

The attempt to find a better tube material than Admiralty brass has failed, and the standard tube today is a heat-treated Admiralty-mixture tube whose material coefficient is 0.98. This coefficient can now be neglected. A number of experiments with dirty and oxidized tubes have been made, but since it is possible to clean a tube by mechanical means and secure the original heat transmission, the cleanliness coefficient may be also neglected in design and only used in checking up a condenser test where allowance must be made for a dirty tube condition.[2]

Assuming that I had practically air-free steam in the experimental apparatus and clean tubes, the value of K is $U\theta^{0.125}/V_w^{0.6} = 470$. The value 630 given in my paper was arrived at by assuming an air pressure of about 0.065 in. of mercury. If the air-term influence be taken to the second power, $K = 570$. In both cases 90 per cent cleanliness and 0.98 for material were assumed.

We know that the results of single-tube experiments may be approached in real condensers, and the closer the approach when the condenser is supplied with sufficient steam the better the performance of the condenser. We know that they never can be approached with light loads or with colder water, because only so much heat is transferred as is present. This definitely prevents the use of Jordan's "mass flow" formulæ or the electric resistance simile. These hypotheses can only be true where no change of state takes place, and this condition is entirely foreign to heat transfer as met with in condenser practice.

We may now put down the following principles:

- *a* The law of temperature rise in the tube is of the exponential form, with $0.875 = 7/8$ (0.9 or 0.8, perhaps) as the exponent.
- *b* We may neglect viscosity for design purposes in America where the water temperature is 65 to 70 deg. fahr. and the vacuum 28 in. and over.
- *c* We may also neglect critical velocity, since all condenser velocities are far above it.
- *d* For velocities in condenser practice we may take K as varying as the 0.6 power of the velocity.
- *e* The reduction in heat transmissive power due to air is very approximately covered by the use of a term $(P_s/P_t)^2$ as a reducing factor of K.
- *f* For design work we may reduce the value of K once for all to account for the cleanliness of the tube and the material itself.
- *g* The value of K will then be reduced to somewhere between 300 and 400 for design purposes, say 325 for average good working.

[1] Trans. Am.Soc.M.E., vol. 37, p. 975.

[2] Trans. Am.Soc.M.E., vol. 32, p. 1135.

[1] Trans. Am.Soc.M.E., vol. 34, p. 713.

[2] Report of Com. on Prime Movers, Natl. Elec. Light Assn., 1916.

CONDENSER DESIGN

THE AUTHOR'S METHOD

Condenser specifications usually call for the condensation of a certain amount of steam per hour, W (lb.), and the maintenance of a vacuum referred to standard barometer or absolute pressure, P_v, with condensing water at a certain temperature, t_o. The quantity of condensing water, Q, the hot-well temperature, t_s, the power used by the auxiliaries and the steam consumption of the auxiliaries may be also specified, but the problem is reasonably determinate when W, P_v, and t_o are known. It is important that the place of measurement of the vacuum P_v be specified, as there is a well-defined drop through most condensers, the vacuum being greatest at the air-pump suction, less in the condenser, and least at the prime-mover nozzle. This drop may amount in well-designed condensers to 0.2 in. of mercury. The specified vacuum should be measured at the prime-mover nozzle, and the designer, according to his judgment, will then allow 0.1 to 0.2 in. for the drop in the condenser.

The absolute pressure in the condenser will then be 29.92 — (vacuum + 0.2 in.) = P_v. The steam tables may now be consulted and t_s the temperature corresponding to the vacuum, λ = the total heat and q = the heat of the liquid be taken therefrom. The final temperature of the condensing water approaches t_s, and for close work may be $t_1 = t_s - 5°$. In ordinary practice, $t_1 = t_s - 7°$, or in some cases 8° or 10°. The ratio of condensing water to steam condensed, which is $R = \frac{\lambda - q}{t_1 - t_o}$, may next be found. Many designers consider it close enough to use 1000 for $\lambda - q$, on account of the moisture in the exhaust steam, and some few use 968. I prefer to use $\lambda - q$ not on account of its accuracy but as a slight factor of safety. Q, the quantity of condensing water = WR in lb. per hour.

At this point the size and thickness of the condenser tubes as well as the water velocity must be chosen. Most of the large installations in Eastern United States use 1-in. tubes on account of bad water conditions, although it has been stated that smaller tubes are more efficient (*vide* Weighton, Neilson, and Weir). There are no definite experiments to decide this point, although from Loeb's work on ¾-in. tubes we may deduce a value of $K = 600$ against $K = 470$ for my experiments on a 1-in. tube. Nevertheless, it is doubtful if anything is saved by the use of anything smaller than ¾-in. when the pumping head is considered. 1¼-in. tubes have also been used, but the consensus of opinion seems to be that a 1-in. tube can be cleaned better, keeps in good condition longer, and can be made better than either smaller or larger tubes. Let us take 1-in. tubes, No. 18 B.W.G., as standard. The formulæ may readily be altered for other sizes of tubes when the constants are known.

With 1-in. tubes velocities from 7 to 10 ft. per sec. are now usual. We may take 8 ft. per sec, as the standard value for V_w.

The number of 1-in. tubes in one pass will be given by the formula

$$n = \frac{Q}{990\, V_w}.$$

The length of water travel (l), or the total tube length, may be found from

$$l = \frac{30.8\, Q}{325\, V_w^{0.6}\, n} \left[(t_s - t_o)^{0.125} - (t_s - t_1)^{0.125} \right]$$

and the total tube surface S from

$$S = 0.262\, nl$$

With 1-in. tubes from 40 to 80 will occupy 1 sq. ft. of tube-plate area, depending on the spacing and general design. The average will be about 60, making the cross-sectional area of the condenser (sq. ft.) equal to ($n \times$ number of passes) ÷ 60. If there are two passes the length of the condenser will be $L = \frac{1}{2}l$ + depth of water boxes.

BEST TUBE LENGTHS AND TEMPERATURE RISES

The paper here gives the condenser formulæ proposed by Neilson in his paper read before the Institution of Engineers and Shipbuilders of Scotland, together with those published in Morrow's Steam Turbine Design, and in Bauer and Lasche's Marine Steam Turbines. These writers use the arithmetical mean for the mean temperature difference. Neilson says, "Equations for θ_m involving the use of hyperbolic logarithms are not to be recommended for condenser design," the reason being that the steam-air mixture in the condenser is not homogeneous. Weighton, upon whose experiments Morrow's work is largely founded, did not consider θ at all in his paper. Many other authorities follow this rule also, and I must acknowledge this position to be correct providing that equal increments in the temperature rise of the water in the condenser tube accompany equal increments of length. The tests of Smith and Josse as well as my own have definitely proved that this is not so. Thermometers placed in the water boxes of any two- or three-pass condenser will also show this fact very plainly.

Now for each curve of temperature rise except the arithmetic there is a definite relation of l/d which is best for any given condition. Under the arithmetical law any values of d, n, and l which will give the necessary surface should be equally efficient, and 10 tubes 100 ft. long should work as well as 1000 tubes 1 ft. long from the heat-transfer standpoint.

The differences between the logarithmic law and the exponential with an exponent between 0.9 and 0.8 are quite small, but the length of the tube required by the formulæ is considerably shorter using the logarithmic formula. These length formulæ may be derived from the expressions for S given in the fourth column of the table on p. 1152, vol. 32, Trans. Am.Soc.M.E.

Taking the steam temperature t_s at 90 deg., the entrance water temperature t_o at 70 deg., and the discharge at 80 deg., with a water velocity of 8 ft. per sec. and 1-in. tubes, I figure the best tube lengths and temperature rises as follows:

	Tube Length, Ft.	Rise in Deg. Fahr.
Arithmetical Law	23.2	0.4310 deg. per ft. of tube
Logarithmic Law	24.0	0.4918 deg. in first foot
Exponential Law (exponent = 0.875)	26.8	0.5624 deg. in first foot

It is to be hoped that some investigator will definitely settle this question on which so much in condenser design depends.

The paper gives a logarithmic chart for the ready determination of such fractional and decimal powers of numbers as are called for by the formulæ given.

WATER FOR STEAM BOILERS—ITS SIGNIFICANCE AND TREATMENT

By ARTHUR C. SCOTT, DALLAS, TEX.
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Non-Member

IN recent years the value of a critical analysis of production costs and operating efficiencies has become prominent in the business of manufacturing, and since water is necessary for the operation of nearly every industrial establishment, its *quality* is receiving more attention than formerly. The plant owner is rapidly modifying his views heretofore concerned only with the available quantity, because of the important factor in the operating cost due to the use of water unsuited to the service required. This is especially significant in steam making.

No general source of water supply, whether lakes or ponds of surface water, rivers, or wells of varying depth, is free from impurities obtained either from filtration through the earth or from the air, or from both.

Water from lakes or large reservoirs is ordinarily most satisfactory for boilers, since it is chiefly rain water and surface drainage, and the suspended matter has had opportunity to settle. Under conditions of a long drought, however, as the reservoir capacity is reduced, the organic matter from algal growth and other sources may have an appreciable effect upon the quality of the water.

River water is more or less variable in character, depending upon the location and extent of the watershed or drainage basin and upon the rainfall. Slow-moving rivers may carry a large amount of mud, some of which settles out readily, while the red or yellow mud will generally remain in suspension a long time unless some coagulant like sulphate of alumina is used. A river frequently picks up considerable organic matter, which by decomposition forms organic acids that corrode boiler metal. The character of the drainage area of a river will affect the character and content of dissolved mineral matter in the water, and this will vary more or less with the season of the year and may vary from day to day part of the time.

Well water varies in quality with the location and depth of well and with the rainfall. Water from deep-well sources is usually low in organic matter but contains mineral constituents dissolved by the water in passing through the earth.

BOILER FAILURES AND LOSSES DUE TO SCALE

Reports show an increased number of dangerous defects in boilers from year to year due to scale, corrosion, priming, etc. Aside from the dangerous condition of a "scaly" boiler, scale also means fuel waste, ranging according to the thickness from 2 per cent for 1/64 in. thickness, to 90 per cent for ¾ in. as a general average.

Other troubles through scale are clogged feed pipes and water- and steam-gage connections, and valves prevented from completely closing.

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WATER-SOFTENING PROCESSES

The common methods of reducing scale troubles are:

a two types of cold processes for the actual softening of water: the intermittent originating with Clark in 1841 and the continuous invented about 1867
b the hot process
c live-steam purifiers
d boiler compounds

For very large plants where several hundred thousand gallons per day are used, a considerable expenditure is justified for tanks and mechanical equipment for the cold process of purification, which is fundamentally a treatment of the water with proper amounts of milk of lime and soda ash. These cold processes perform their chief service in softening water for locomotives and in large plants where water is used in considerable quantities in connection with jet or barometric condensers, or where it must be softened for other purposes than boiler feed alone.

The hot process is particularly desirable for plants where exhaust steam is available. Purification of the water is partly obtained by heating to the approximate boiling point, but sufficient soda ash is added to satisfy the alkaline earth sulphates and chlorides and any acid present. The essentials are heat and soda, and the whole scheme is virtually embraced in the ordinary operation of an open-type feed-water heater, with the introduction of soda ash into the hot water.

Live-steam purifiers are useful as partial purifiers, but are always subject to boiler pressure, waste some heat, must be placed higher than the boiler level, and frequently give trouble from water hammer.

Boiler compounds are more or less palliative in their action and produce results by (*a*) acting as chemical reagents combining with the scale-forming impurities, breaking them up and precipitating them as sludge; (*b*) acting mechanically on the precipitated scale-forming matter and entrapping it as it is precipitated from solution before it has formed a hard, adherent scale. Examples of materials in use under (*a*) are soda ash, caustic soda, trisodium phosphate, sodium fluoride, and compounds of tannin; and under (*b*) gelatinous or starchy materials, such as ground bones, hoofs, horns, slippery elm, and potatoes.

Boiler compounds are to be recommended for use only in small plants whose capacity will hardly justify arrangements to purify the water before it enters the boiler. The steam boiler should be used primarily for generating and storing steam energy, not as a precipitating tank. If it must be used partly as the latter, it is most economical to have the feed water analyzed, and the character and amount of chemical reagents determined to effect the necessary purification. These reagents, of definite strength and known amount properly proportioned for the conditions, should be pumped in with the feed water as it passes into the boiler.

BLOWING OFF BOILERS

The main factors in ordinary boiler-water purification are heat, soda ash and blowing off, with possible filtration when this can be arranged, as is sometimes done with the hot process. The blowing off is important. It should be done under low pressure to be effective in carrying out the sludge and to reduce the boiler stresses coincident with rapid blowing under high pressure. If it must be done under high pressure, the

valves should only be "cracked"; otherwise only a small part of the sediment will be carried out, because the vortex or whirlpool formed draws down clear water, leaving the main body of the sludge intact.

Undoubtedly some of the troubles recorded as due to scale-forming water are really attributable to the disregard of proper methods of blowing off, and to the pumping in of cold water, thereby overstraining the boiler material.

KEROSENE FOR SCALE TROUBLES

The success of kerosene oil in removing and preventing scale is undoubtedly due to mechanical action alone. To be effective the oil should be put in after the boiler is emptied and washed, and the boiler should be refilled slowly from the bottom. It is useless to pump the kerosene in with the feed water, for it may tend to form a non-conducting film over the heating surfaces that will introduce an element of danger.

BOILER TROUBLES CAUSED BY CORROSION

The trouble due to corrosion of sheets, tubes, stays, etc., is in some cases more acute than ever occurs with scale. Carbonic acid gas, occluded oxygen, and sodium and magnesium chlorides are the most frequent offenders, and the chlorides are so difficult to remove that the cost is practically prohibitive.

Corrosion due to the chloride ingredients is particularly destructive to steel boiler tubes, hot-water piping, and brass-seated valves. Galvanized steel pipe is not immune, because any defect in the zinc coating permits local galvanic action, with consequent rapid destruction of the zinc coating. Water with as much as 500 parts to a million of these chlorides, especially when hot, is destructive to steel pipe and fittings.

Waters are frequently both scale-forming and corrosive; usually a water having a corrosive tendency will be more or less scale-forming. Caustic or carbonate alkalies or caustic lime act as neutralizing agents for corrosive ingredients, but must be carefully handled or the scale-forming matter will be increased. Their use should be confined to treatment of the water outside the boiler if possible.

BOILER TROUBLES DUE TO FOAMING OR PRIMING

Boiler troubles due to foaming or priming apparently depend largely upon the concentration of alkali salts in the water, although silt, organic matter, loosened scale, lubricating oil, character of load and design of boiler all have an appreciable bearing upon this phenomenon.

Surface blowing is a remedy where it can be applied, and usually the proper use of the main blow-off will reduce the concentration of salts in the boiler.

There are many natural waters of sufficient alkali content to produce immediate foaming whenever the pressure at the surface of the water in the boiler is relieved by the sudden and large use of steam. As there is no chemical treatment that will precipitate alkalies from solution, such waters are to be rejected for boiler use.

WATER TREATMENT

CHEMICAL PROCEDURE IN WATER SOFTENING

Excepting waters containing hydrogen sulphide, all natural waters contain the same ingredients. The analytical chemist makes the same determinations in the same way on every sample of water which he investigates, unless the water contains hydrogen sulphide. He determines silica, iron oxide, and alumina, together with the following important basic and acid ions:

Basic Ions (*B*)	*Acid Ions* (*A*)
Potassium and Sodium	Chlorine
Magnesium	Carbonic acid
Calcium	Sulphuric acid

Were it possible to make all the determinations without experimental error, the basic ions (B) would be found present in just the right amount to combine with the acid ions (A), forming "salts." Chemists universally regard the ions as the form in which salts exist in solution, but engineers are more accustomed to water analyses expressed in the form of salts. When so given the nature and amount of chemical treatment necessary for softening water are very clearly shown.

In the discussion of boiler waters it is well to divide the salts present into (1) the alkali salts, that is, the salts of potassium and sodium, and (2) the calcium and magnesium salts. The alkali salts do not crystallize out under the conditions attained in the boiler, and therefore cannot produce scale. Apart from the small amount of silica, oxide of iron, and alumina, the scale formed in boilers is due entirely to calcium and magnesium salts. These are commonly spoken of as constituting the hardness of water, and it is customary to divide hardness into two kinds—temporary and permanent.

HARDNESS IN WATER AND ITS REDUCTION

The combined bicarbonates of magnesium and calcium constitute temporary hardness, while the other salts of magnesium and calcium constitute permanent hardness. Temporary hardness can always be expected in river, spring, and well waters, but a great many waters do not possess permanent hardness. Waters with less than 8 grains per gallon of scale-forming material are considered very good; 8 to 15 grains good; 15 to 20 fair; 20 to 30 poor; 30 to 40 bad, and over 40 very bad. Scale due principally to temporary hardness will deposit as a loose sludge, readily blown off. Where the ratio of permanent to temporary hardness exceeds 1 to 4, the scale will be hard, cement-like, and very adhesive to boiler metal.

Water treatment, or softening, removes the greater part of the calcium and magnesium. The bicarbonates are removed practically altogether, but of the sulphates and chlorides the calcium and magnesium are removed and the SO_4 and Cl left in the water. As an equilibrium must exist between the basic and acid ions, other basic ions must be substituted by adding soda ash.

When water is softened outside the boiler and the sludge removed by sedimentation and filtration before the water enters the feed-water heater, the chemicals used in the treatment are either lime alone, or lime and soda ash. If the lime and magnesium are present as temporary hardness alone, that is, as bicarbonates with the sulphates of these bases absent, lime suffices for the chemical treatment. If either the magnesium or both the magnesium and calcium are present in other salts, the lime treatment must be supplemented by soda-ash treatment. No chemicals other than lime and soda ash are used under ordinary conditions in water softening. There are others that would do the work more efficiently, but their cost precludes their use.

The paper here gives the chemical calculations entering into water softening, including those for the reactions and the quantities of the reagents necessary for softening a given water.

CHEMICAL CONTROL IN WATER SOFTENING

No matter what the patent features of a water-softening system may be, it is impossible to regulate automatically the feed of chemicals to compensate fluctuations in the scaling ingredients of the water. The best results can be obtained only by controlling with chemical tests the successive batches of water treated. They require the use of standard acid in connection with two indicators, phenol-phthalein and methyl orange with the use of a standard soap solution.

The paper here gives a list of apparatus needed and directions for performing tests for hardness, causticity and alkalinity. The operator in a softening plant very soon learns how to make use of the knowledge obtained from these tests in producing a satisfactory boiler-feed water.

CORROSION AND FOAMING

Pitting and corrosion in boilers are frequently due to magnesium chloride and less often to calcium chloride. Either of these salts is very pernicious in that on hydrolysis it produces free hydrochloric acid. This action is, however, in large measure counteracted when the temporary hardness runs high. Waters high in nitrates are always highly corrosive. Large amounts of sodium chloride also tend to make waters corrosive. Some waters very low in mineral content produce corrosion, especially at the feed-water intake, owing to a large amount of dissolved oxygen and free carbonic acid. Peaty waters are harmful to boilers by reason of the vegetable acids which they contain. Waters containing a free mineral acid are particularly harmful.

Waters which contain large amounts of alkali salts, especially sodium carbonate and sodium chloride, have a tendency to foam. Suspended matter of any kind increases the foaming tendency. Waters low in mineral content but high in organic matter, though perfectly clear, may also be troublesome. Sodium salts, in most cases sodium sulphate, are augmented in the softening process. Some waters are so high in initial alkali salts that they will not stand a further addition from the soda ash used as softener without producing serious foaming. In such cases barium hydroxide can be used as a substitute for soda ash, although it is expensive. All barium salts that are soluble are poisonous.

From what has been said relative to the effect of large amounts of alkali salts on waters, it is evident that one good result to be obtained from chemical control in water softening is the prevention of an overfeed of soda ash, as any large excess of this chemical will produce a foaming water. The only methods of combating foaming waters appear to lie in frequent blowing off and washing out the boilers, and along lines of improved boiler construction.

THE IMPACT TUBE

By SANFORD A. MOSS, LYNN, MASS.

Member of the Society

THE impact tube as a part of the pitot tube is well known as a means for measuring flow of fluids. When used as a separate instrument, however, it is much more valuable, and has not received the attention it deserves. This paper deals with application of the impact tube to a number of purposes not generally known, particularly relating to compressible fluids. The paper is based on laboratory work of the Steam Turbine Department of the Lynn works of the General Electric Co., Richard H. Rice, Mem.Am.Soc.M.E., chief engineer.

For presentation at the Annual Meeting of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, New York, December 5 to 8, 1916. The paper is here printed in abstract form, and advance copies of the complete paper may be obtained gratis upon application. All papers are subject to revision.

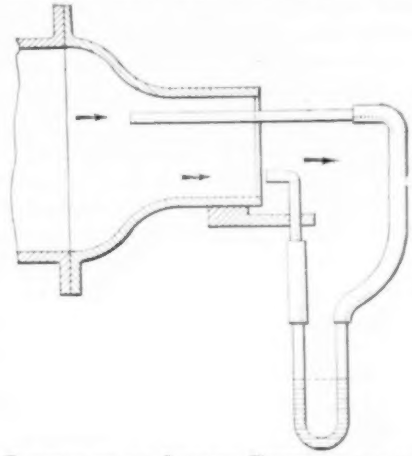

FIG. 1 CONSTANCY OF IMPACT PRESSURE OF AN ORIFICE

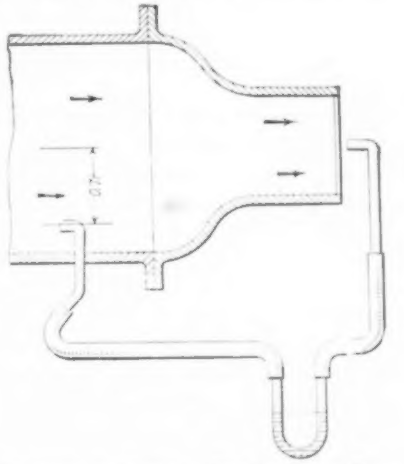

FIG. 2 EQUALITY OF IMPACT PRESSURE IN PIPE AND JET

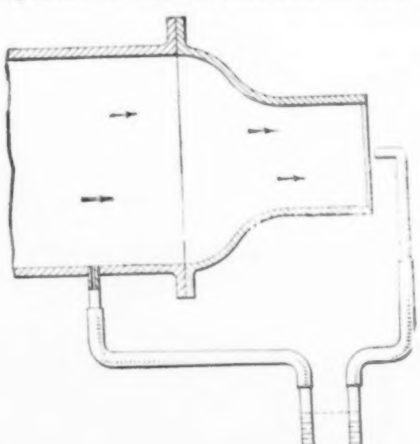

FIG. 3 VELOCITY HEAD SHOWN BY DIFFERENCE BETWEEN PIPE STATIC AND JET IMPACT PRESSURES

LAW OF THE IMPACT TUBE

The law of the relation between velocity and the differential pressure (difference between the readings of an impact opening and a true static opening) is well known for incompressible fluids or where the compressibility effect is negligible, such as

air and steam at comparatively low velocities. This law is usually given in the form $V = \sqrt{(2\,gh)}$, where V is the velocity in feet per second, and h is the height, in feet, of a column of the fluid in question having a pressure equal to the differential pressure.

The impact tube is not restricted to use where the above formula applies, however. Very high velocities with compressible fluids can be measured accurately if the complete law is used. This law is that *the impact tube perfectly converts velocity into pressure.* That is to say, the velocity of the fluid in front of the impact tube is exactly that which would be produced by theoretical adiabatic flow from a region where the absolute pressure is that shown by the impact tube, to a region where the absolute pressure is the static pressure. We may, therefore, use the theoretical thermodynamic formulæ for adiabatic flow through orifices, deduced with the assumption that the initial velocity in the pipe preceding the orifice is practically zero. This law holds for steam, air and all gases, as well as for liquids.

The flow of a gas thus computed is somewhat different than if computed from $V = \sqrt{(2gh)}$. This difference is negligible if the differential pressure is a small fraction of the absolute static pressure. The error is appreciable with air with a pressure of 1 lb. per sq. in. above atmosphere, with velocities of about 50 ft. per sec., and becomes more and more serious as velocity increases.

The law of the impact tube follows directly from the general law that *impact pressure is constant at all points as we proceed up the stream along an orifice fed by a very large pipe.* It has been known for some time that this law holds for liquids. It may be extended to the case of high velocities and compressible fluids. Demonstration of this law is readily made with apparatus shown in Fig. 1. A stationary impact tube is clamped at a convenient point in the jet from a convergent orifice preceded by a large pipe. An impact tube, moved by hand, is arranged to be pushed up inside of the orifice. Differential pressure between the two tubes is shown by a water U-tube. It will be found that the differential pressure is zero. The law is certainly accurate to within about ¼ of 1 per cent of the orifice impact pressure, and probably is absolutely accurate.

INITIAL VELOCITY HEAD

The apparatus above mentioned shows, when the pipe preceding the orifice is more than about three times the orifice diameter, that the jet issuing from the orifice into the atmosphere has a constant impact pressure, and hence a constant velocity, at all points over its area except very close to the edges.

The velocity in a long straight pipe preceding an orifice is not constant but is proportional to the ordinates of an ellipse, being a maximum in the center and gradually decreasing toward the sides of the pipe. When this pipe velocity is not negligible compared with the spouting velocity, the experiment of Fig. 1 shows that the static pressure in the pipe preceding the orifice plus the average velocity head at this point is equal to the impact pressure in the jet issuing from the orifice. The sum of the initial static pressure and the average velocity head is given by an impact tube in the pipe preceding the orifice placed at such a radius as to give the average velocity head. If the pipe preceding the orifice is quite large, the point where the velocity head has the average value is at about 0.7 of the radius. Hence, a water U-tube arranged as in Fig. 2 reads zero. For the same reason, the water U-tube in the experiment of Fig. 3 reads the average velocity head in the pipe preceding the orifice.

CONVERGENT-DIVERGENT ORIFICES AND VELOCITIES GREATER THAN VELOCITY OF SOUND

For a compressible fluid where the final pressure is greater than about half the initial pressure, an orifice must be wholly convergent just as for incompressible fluids. In such cases, the velocity of the jet issuing from the orifice is less than the velocity of sound. The above impact-tube laws, as well as all of the work with impact tubes here discussed, apply only to such cases. With a gas, when the final pressure is less than about half the initial pressure, the orifice must be first convergent and then divergent. The writer has not carefully investigated impact tubes under these conditions. There is an indication that they do not convert velocity into pressure with 100 per cent efficiency. It can be said, however, that with a final pressure less than half the initial pressure, and with a wholly convergent nozzle (a shape which does not give full theoretical velocity), the impact pressure in the jet close to the end of the orifice is equal to the initial pressure. In this case, it is known that the static pressure of the jet is about 52 per cent of the initial pressure for air, and 58 per cent for steam, regardless of the pressure of the region into which the jet discharges, and that the jet velocity is the velocity of sound. The jet itself forms stream lines, creating an extension of the orifice, and representing a divergent portion where pressure decreases to the pressure of the surrounding region and where velocity increases from velocity of sound to a somewhat greater value, which is less, however, than the value that may be obtained by using a properly shaped orifice.

ADVANTAGES OF THE IMPACT TUBE OVER THE PITOT TUBE

The writer believes there is no reason for using the common form of pitot tube. This is a double-walled tube consisting of an impact tube pointed upstream surrounded by a chamber with openings for determining the static pressure. It has been known for years that the impact portion of this tube gives reliable results, regardless of its shape. On the other hand, the static holes give very indefinite results and the shape and sizes of all of the parts have influence on the static readings. Measurements made by use of a plain impact tube in conjunction with a static hole in the pipe wall will give results that are identical with those obtained by using an accurate form of pitot tube.

Parallel flow in a pipe is only possible when the static pressure is absolutely the same at all parts of a section perdendicular to the stream. Therefore, if there is variation in the static pressure the stream angles will be such that even an accurate form of pitot tube will give erroneous results. The pitot tube, therefore, offers no advantage over the combination of an impact tube and a static hole in the pipe wall. On the other hand, it is much easier to make a reliable static hole in the pipe wall than it is to make a reliable static hole in the pitot tube. The usual trouble with pitot tube static openings is that they give too low a reading for static pressure. This increases the small difference reading between impact and static sides and indicates a quantity larger than actually exists.

DEDUCTION OF THE IMPACT TUBE LAW FOR GASES

A gas in a closed envelope consists of a number of molecules darting hither and thither at high velocities, and a gas flowing in a pipe consists of molecules with velocities such that the average velocity downstream has a definite value, the velocities across the stream cancelling so that the average is zero. Hence, if gas is flowing from a large vessel through a properly shaped orifice into a region of lower pressure, the molecules in the jet issuing from the orifice are really in the same condition as those in the vessel, except that there is a general net velocity which we call the velocity of the jet. The net velocity is at once destroyed, however, if anything is inserted in the jet, so that the molecules immediately in front of the impact tube in a discharge jet are in exactly the same condition as those in the large vessel from which the gas issues. Hence, the impact

Fig. 4 Fig. 5

Fig. 4 Single Static Hole in Pipe Wall
Fig. 5 Ring of Static Holes in Pipe Wall

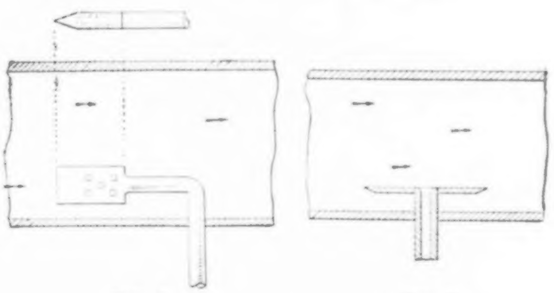

Fig. 6 Fig. 7

Fig. 6 Static Pressure Boat
Fig. 7 Static Pressure by Side Gage

tube in the jet must measure the same pressure as would a static hole in the pipe wall of the large vessel.

IMPACT TEMPERATURE

A similar situation occurs if a thermometer is placed in a high-velocity jet in an attempt to measure its temperature. The molecules surrounding the thermometer are immediately restored to the same condition as those in the large vessel from which they originally proceeded. Hence, as can be demonstrated by experiment, a thermometer inserted in a high-velocity jet issuing from an orifice will give nearly the same reading as a thermometer in the large vessel from which the jet discharged.

A gas discharged from an orifice, from the ordinary point of view, has a very low temperature, resulting from adiabatic expansion. Actually, however, this temperature is only relative to a thermometer moving with the velocity of the jet. The individual molecules have the same average kinetic energy and hence the same temperature as they originally had.

Temperature measurements have been made and published which show temperatures in a high-velocity jet of air much above the theoretical adiabatic temperature of the jet. It was alleged that these experiments showed that the velocity of such a jet was not really the theoretical velocity due to adiabatic expansion, and that it was not possible to expand a gas in a nozzle so as to obtain such a velocity. This conclusion is incorrect, however, and with a properly shaped orifice or nozzle, nearly the full theoretical velocity due to adiabatic expansion can be attained with air or any gas, just as with steam in a steam turbine. If the energy is extracted from the jet by a turbine wheel or the like, the exhaust will show low temperature. If, however, no energy is extracted but if the thermometer is inserted directly in the high-velocity jet, nearly initial temperature will be shown.

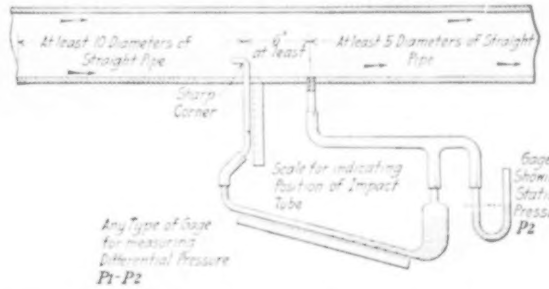

Fig. 8 Impact Tube and Hole in Pipe Wall for Measuring Pipe Flow

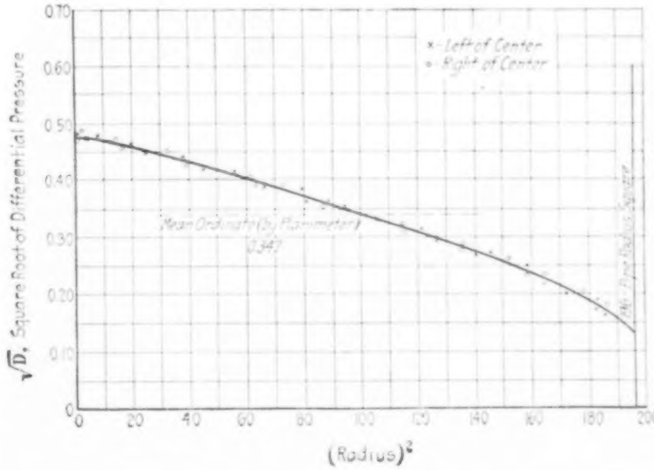

Fig. 9 Curve of Pipe Flow Test by Impact Tube Traverse

The mean ordinate of a smooth curve through the points, as found by a planimeter, gives the square root of the impact pressure difference, $\sqrt{D}$, which is to be inserted in the formulae.

In the Bradley and Hale experiments on temperature of air after great expansion,[1] thermometers directly in the high-velocity jet showed a lower temperature than those a little further away where the velocity had been destroyed. This is probably due to the fact that the orifice which was demanded by the pressure ratios involved should have been first converging and then diverging.

IMPACT TUBE ARRANGEMENT

The exact shape of the impact tube is not important. It is only necessary that there be a pipe or tube facing squarely

[1] Physical Review, 1909, v. 29, p. 258

upstream in a jet undisturbed except by the impact-tube end. The impact-tube end, therefore, should have a straight portion parallel to the jet about 10 times the length of the impact-tube opening, before the tube bends away from the jet. The open end of the tube should be slightly rounded on both inner and outer edges and should be smooth. For ordinary work, the tube is $\frac{1}{4}$ in. to 1 in. in diameter. For work with small pipes, and for special exploration work, the tube may be of any size. The writer has obtained satisfactory results with tubes as small as $\frac{1}{32}$ in. outside diameter.

The impact tube must face squarely downstream. There is no necessity for exact measurement in this connection, however, and estimation by eye is accurate enough.

STATIC HOLES IN A PIPE WALL

Figs. 4, 5, 6 and 7 show different methods of obtaining static pressure. Fig. 4 shows how actual pressure is obtained by means of a hole in the pipe wall. The inner surface of the

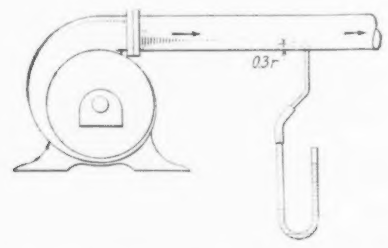

FIG. 10 IMPACT TUBE GIVING TOTAL PRESSURE RISE WITH ATMOSPHERIC INLET PRESSURE

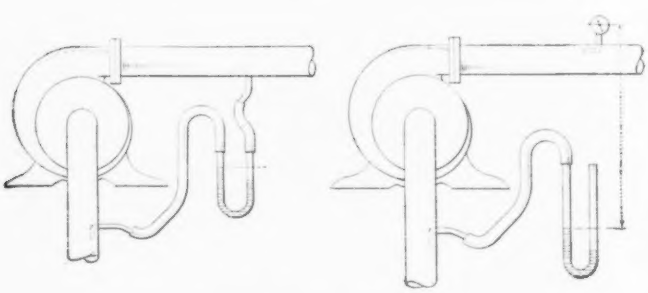

FIG. 11 IMPACT TUBES GIVING TOTAL PRESSURE DIFFERENCE BETWEEN INLET AND DISCHARGE PIPES

pipe adjacent to the hole must be smooth. The hole must be at right angles to the surface and there must be no burrs. The inner corners should be rounded with a radius 1/10 to 1/50 of the diameter of the hole. Fig. 6 shows a number of static holes. This form is in very common use and it is supposed that any variation in static pressure is averaged. It is questionable whether any advantage is obtained, however, from the multiplication of holes.

For any of these types, the pressure holes must be of good size. They should be at least $\frac{1}{4}$ in. in diameter and preferably $\frac{1}{2}$ to 1 in. to avoid a drop of pressure which might occur with a small hole and a minute leak. One of the disadvantages of the common form of pitot tube is that the static holes are often so minute that the pipes to the pressure-measuring instrument must be extraordinarily tight to secure accuracy. On the other hand, if a large hole is used in the pipe wall or the equivalent, as in Figs. 4, 5, 6 and 7, and if the impact tube is made of good size with the opening $\frac{1}{4}$ to 1 in. diameter, a slight leak will not have very serious effect.

TIGHTNESS OF PIPING

It is desirable to use large pipes for connecting the static and impact tubes with the measuring instrument. Standard $\frac{1}{4}$- or $\frac{1}{8}$-in. piping should never be used for such purposes unless the connecting lines are very short. When the piping is of any great length, $\frac{1}{2}$-in. pipe or even 1-in. pipe should be used, because it is much easier to make the larger-size pipe tight, and because even a small leak will not cause much of a pressure drop. It is to be noted that the differential pressure measured is usually quite small, so that even a slight error in either pressure will cause an appreciable error in the differential.

The paper here gives methods of test for tightness of piping applying to pitot and impact tubes, flow-meter work, venturi-meter work, etc.

IMPACT TUBE AND HOLE IN THE PIPE WALL FOR MEASURING PIPE FLOW

The apparatus is to be arranged as shown in Fig. 8. However, instead of the single static hole as shown, other means

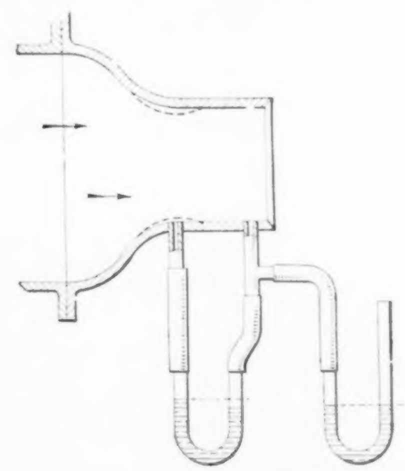

FIG. 12 APPARATUS TO SHOW CONTRACTION AT END OF CONVERGENT PORTION OF AN ORIFICE

of securing static pressure can be used, as shown in Figs. 5, 6 or 7. If methods of Figs. 6 or 7 are used, the impact tube must be placed at such a distance from the static tube that neither instrument will disturb the flow past the other.

There are numerous well-known forms of the differential gage which may be used.

If any of the tests give flows large enough to show a differential pressure of 1 in. or more of water vertical, it is desirable to connect up a vertical water U-tube in parallel with the differential gage.

The impact tube should be pushed clear across the pipe, readings being taken at both sides with the tube in contact with the pipe wall, and at a number of points between. One method is to space the positions at distances proportional to the square of the radius. Then the arithmetic mean gives a number properly weighted for the various areas involved.

The writer has found it satisfactory to measure the actual radius with each setting, spacing settings somewhat more

closely at the edges than at the center. The various readings are then plotted as shown in Fig. 9, readings on both sides of the center being plotted together. The square of the radius is plotted against the square root of the differential pressure. The mean ordinate of such a curve gives the mean square root of the differential, properly averaged for use in the formulæ given in the paper. The static pressure is also to be measured independently. The computation work is slightly simpler if this is taken rather than impact pressure.

IMPACT TUBE FOR MEASURING PIPE PRESSURE

When a fluid, either liquid or gas, is flowing in a pipe, it is frequently desirable, for general purposes, to use the impact pressure rather than the static pressure. An example of this is pressure in a pipe preceding a venturi meter or other form of orifice in a pipe line. The ordinary formulæ involve this pressure as well as the pressure at the throat or orifice end, and include a very troublesome corrective term for the initial velocity at the point where the initial static pressure is measured. If, however, this initial pressure is measured by use of an impact tube, the velocity head at this point is automatically added to the static pressure and a net pressure obtained, equal to the pressure which would have been obtained if the pipe preceding the orifice had been large enough to render the velocity head in it negligible. The formulæ for this case (given in paper) are very much simpler than those usually given, in which the initial velocity has to be taken into account. Of course, if there is any foreign matter in the stream, it is likely to clog the impact tube, in which case this arrangement can not be used. In such a case, initial pressure must be measured by means of a hole in the pipe wall, and the ordinary formulæ which take account of initial velocity must be used.

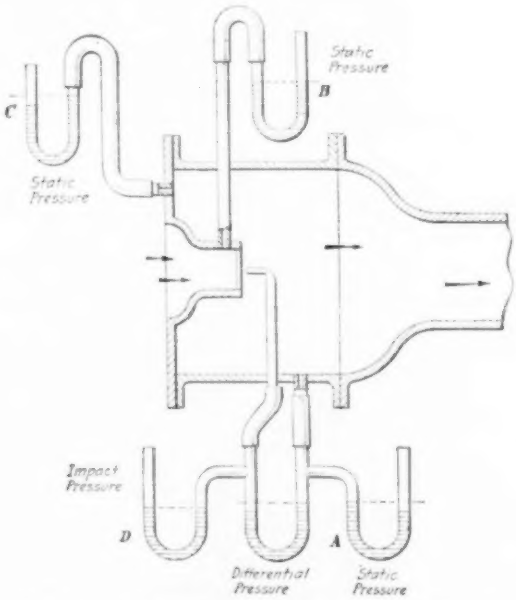

FIG. 13 ORIFICE DISCHARGING INTO AN ENCLOSED REGION

The static pressure of region into which jet discharges must be taken in a number of places, such as *A*, *B* and *C*, and seen to be exactly the same.
If the orifice is supplied from the atmosphere, the impact pressure *D* will be zero.

Another case in which it is convenient to measure the impact pressure is in finding the total pressure rise produced by a centrifugal pump or centrifugal compressor. If the discharge pipe of such a machine is very large, the velocity head in it is negligible, and the pressure produced is the static pressure. If, however, the pipe is small enough to give an appreciable velocity head, as is often the case with fan blowers and centrifugal compressors producing a pressure of 2 or 3 lb. per sq. in., the energy actually put into the air by the machine is completely shown by the impact pressure. It is really correct to compute the efficiency of the machine on the basis of impact pressure. The arrangement is shown in Fig. 10. A similar arrangement can be used in the case of centrifugal pumps. If the inlet and discharge pipes are both of the same size, impact tubes give the same difference as static holes. If, however, the inlet pipe is larger than the discharge pipe, as is often the case, impact tubes in both pipes automatically take account of the difference in velocity heads. The difference in the pipe pressures as shown by the impact tubes, plus the head equal to the vertical height differences, gives the total work done by the pump. The arrangement is shown in Fig. 11. These remarks do not apply to the case of pulsating flow, as with a reciprocating machine.

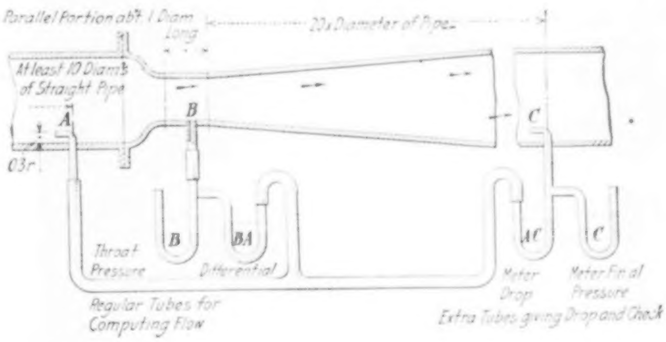

FIG. 14 VENTURI METER WITH IMPACT TUBE AND EXTRA TUBES FOR EXPERIMENTAL PURPOSES

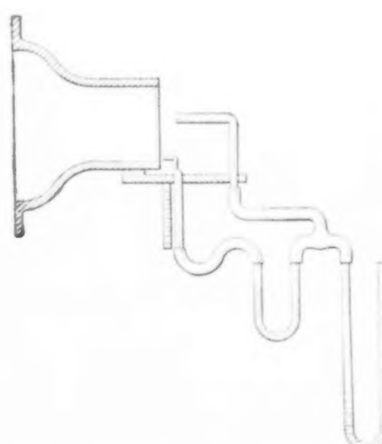

FIG. 15 ORIFICE CALIBRATION BY TRAVERSE OF AN EXPLORING IMPACT TUBE

In all cases, the impact-tube center should be about 0.3 of the pipe radius from the pipe wall.

As an additional advantage in the use of the impact pressure rather than the static pressure, it should be noted that the pressure is obtained more accurately. The tapping of a pressure hole in the pipe wall is very uncertain and it is often easier, particularly in the case of field tests, to insert an impact tube which is certain to give correct pressure, than it is to take the necessary precautions to make sure that a hole in the pipe wall is free from burrs and projections.

SHAPE OF ORIFICES FOR MEASURING FLOW OF FLUIDS

The "orifice" frequently discussed in this article is a smoothly formed, convergent passage. Such an orifice is used at the entrance of a venturi meter, or for measurement of fluid discharged into the atmosphere, as discussed later. The exact shape by means of which the convergent portion is secured is not very important. The writer prefers the general shape shown in Fig. 18, formed by circular arcs. A cone with straight sides, however, is probably equally satisfactory, if the angle is gentle and if there is a smooth circular arc connecting with a straight portion at the end of the orifice.

It is highly essential that there be a parallel portion at the end of the convergent portion, of sufficient length properly to size the jet. At the end of the convergent portion there may be a contraction of the jet, due to the fact that the orifice is not shaped to avoid contraction. The existence of such an effect can never be known except by an actual experiment, as indicated in Fig. 12. If, however, we have an orifice of the shape of Fig. 18, or a venturi meter with the shape of Fig. 14, the parallel portion insures that the jet whose measurement is sought has the exact diameter of this parallel portion.

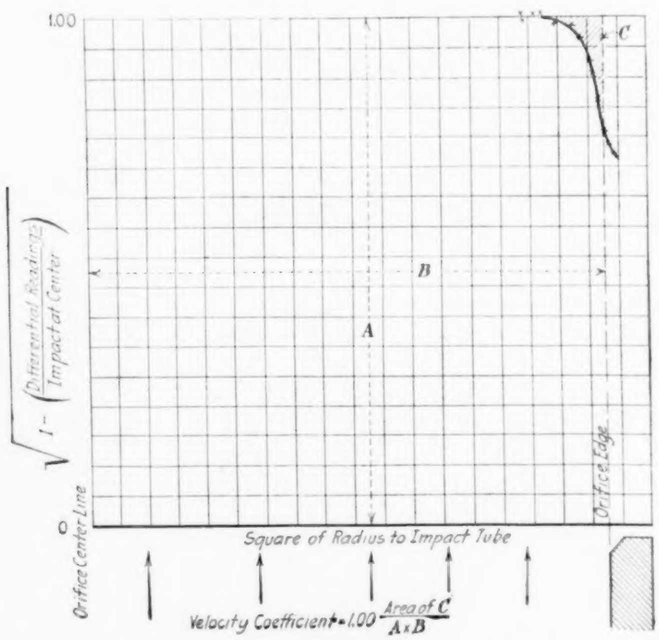

FIG. 16 CURVE OF ORIFICE CALIBRATION BY IMPACT TUBE TRAVERSE

The length of such a parallel portion should be from half diameter to diameter of the parallel portion. Greater length might introduce appreciable friction drop.

A minor point, of practical importance, is the chamfering of the outer end of an orifice. This prevents the edge from being burred or dented during handling and so preserves the diameter of the parallel portion everywhere. The parallel portion must, of course, be carefully machined so as to be exactly parallel and round.

VENTURI METER WITH IMPACT TUBE

The general arrangement is shown in Fig. 14. The use of such an impact tube avoids the computation work necessary to take account of the initial velocity head and the necessity for care in drilling a static hole.

Fig. 14 also shows some additional readings which the writer has found convenient in the case of venturi meters used for experimental testing. The readings will check as follows, if all pipes are tight and the apparatus properly set up. (See Fig. 14.)

If B and C are above atmosphere, the difference between B and AC will equal the difference between C and BA.

If B is below atmosphere and C above, the sum of B and AC will equal the difference between C and BA.

If B and C are below atmosphere, the sum of B and AC will equal the sum of C and BA.

PRESSURE OF A JET DISCHARGING FROM AN ORIFICE INTO THE ATMOSPHERE

The only case discussed in this paper is that in which the final pressure is greater than about half the initial pressure, so

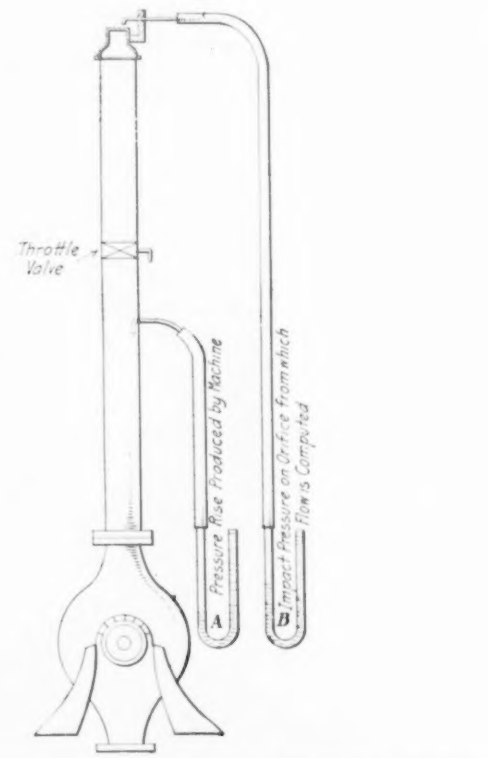

FIG. 17 MEASUREMENT OF QUANTITY OF FLOW BY MEANS OF ORIFICE AND IMPACT TUBE

that the theoretical orifice is wholly convergent. In such a case, ***the static pressure of the jet discharged from an orifice is exactly equal to the pressure of the region into which it discharges.*** This law applies primarily to the discharge of an orifice into the atmosphere. However, it also applies to discharge of an orifice into an enclosed region, such as is shown in Fig. 14, provided there is ample room all around the orifice for a free discharge of jet and no restrictions such as would be likely to cause a venturi-meter effect. The static pressure of the region into which a jet discharges must be measured in a number of places, such as A, B and C, Fig. 13, and seen to be exactly the same. If the orifice is supplied directly from the atmosphere, the impact pressure, D, will be zero. The accuracy of the above law is really the basis of all the impact-tube work here discussed. So far as known, the law has never received any valid criticism.

If the orifice has a parallel portion of appreciable length at the end, the streams of the jet, as they discharge into the atmosphere, necessarily proceed in straight lines. This can also be seen by watching the jet discharging from a water or wet-steam orifice of the proper shape, or by feeling the surface of an air jet. The jet preserves a solid parallel column for quite a distance. If, now, a stream at the edge of the jet and a stream in the interior of the jet are proceeding in parallel directions, there can be no possibility of pressure difference between them. If there were any pressure difference, the flow would be in curved lines. A stream at the edge of the jet, proceeding in a straight line, is obviously at the pressure of the region. Hence, the same pressure exists throughout the cross-section of the jet.

The paper here describes an interesting experiment giving additional verification of the above point.

curate to within ½ of a per cent, so that the coefficient may be somewhere between 0.985 and 0.995. It seems probable that the larger the orifice the greater the coefficient.

It should be noted that this method *gives an accurate calibration of any orifice without measurement of flow by means of tanks, weirs, gas holders, etc.*

Calibration with water orifices and the same general system were made by John R. Freeman, Mem.Am.Soc.M.E., and are described in the Transactions of the American Society of Civil Engineers.[1]

Exploration of Irregular Jets

The same general methods have been used by the writer to find velocities of various types of jets, such as those from the nozzles and stationary buckets of steam turbines.

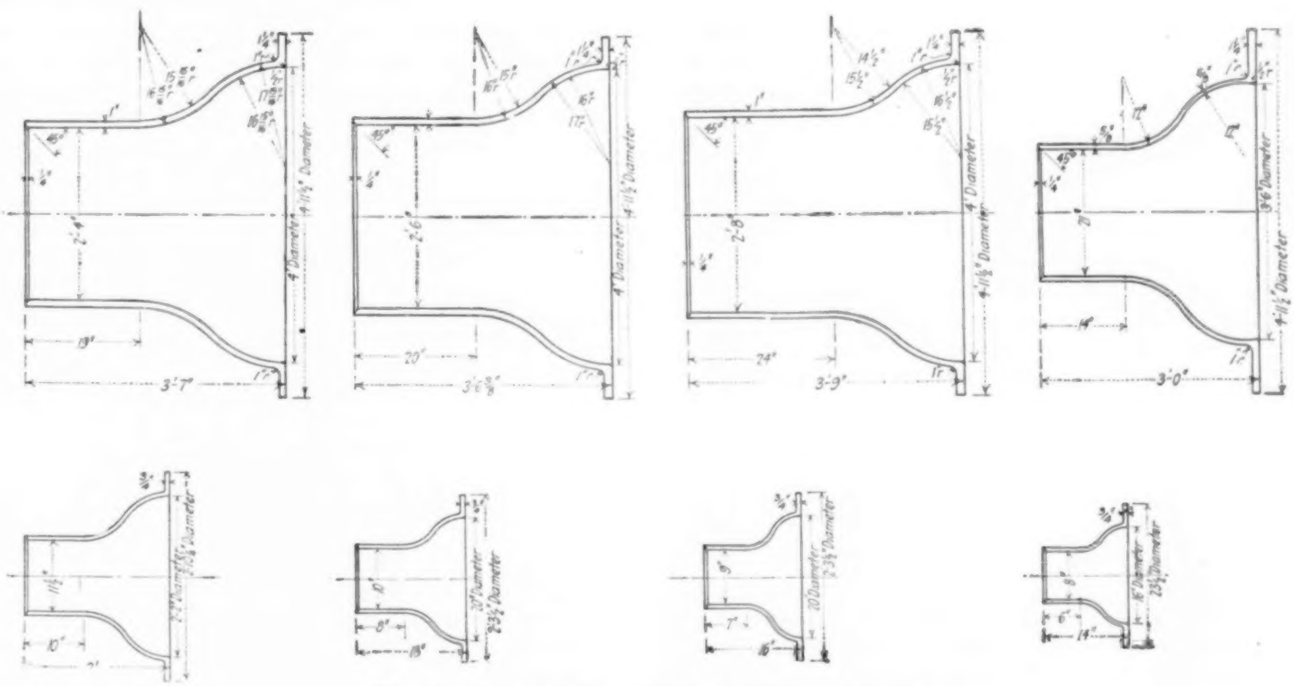

Fig. 18 Dimensions of Some Measuring Orifices

Orifice Calibration by Means of Impact Tubes

Many calibrations of orifices discharging high-velocity jets of air have been made by the writer with the apparatus of Fig. 15. This consists of a stationary impact tube placed in the center of the jet, slightly beyond the plane of the orifice end, and a very small movable impact tube which can make a traverse across the edge of the jet covering a space of ¼ to ½ in. The differential pressure between the two tubes is read by means of a vertical water U-tube, or some more delicate instrument, as circumstances warrant. The impact pressure is constant everywhere in the jet, except for a narrow ring around the edge which is traversed by the small impact tube. An impact tube about 1/32 in. outside diameter has been used with a 4-in. orifice, traversing a space of about ¼ in., and proportionally with larger orifices. The results are plotted in Fig. 16. The ratio of the area of the small corner C to the area AB, of the large rectangle, gives the velocity loss. By subtracting this from unity, the velocity coefficient of the orifice is obtained. Many such tests indicate a velocity coefficient of about 0.99. These experiments have been ac-

Measurement of Discharge of High-Pressure Air by Means of an Orifice and Impact Tube

The general arrangement is shown in Fig. 17. The discharge pipe of the machine which is being measured is connected up with a considerable length of straight pipe to the orifice. It is usually desirable to have a throttle valve in the pipe so that various amounts of flow giving various loads on the machine can be measured by means of a single orifice. It is necessary that there be at least 10 diameters of straight pipe between the throttle valve and the orifice. If it is desired to measure the discharge pressure produced by the machine, it is necessary, in addition, to have about 10 diameters of straight pipe between the machine itself and the throttle valve. An impact tube inserted in this pipe gives the net pressure rise which the machine under test produces, while the impact tube on the orifice gives the volume or quantity passing through. The orifice should be selected by the use of formulæ given in the paper.

[1] No. 426, v. 21, Nov., 1889; No. 479, v. 24, June, 1891; and v. 13, p. 382.

The impact tube is to be stationary and in the center of the jet, slightly outside the plane of the orifice end. The tube is in plain view throughout the test so that it can always be seen to be properly in line and free from obstructions. This is one of the advantages of this method.

The general method here described has been used on centrifugal pumps and fire streams. It is just as convenient with high-velocity jets of air or other gases.

The flow is to be computed by formulæ given in the paper.

The parallel portion at the end of the orifice should have a diameter at least one-third of the diameter of the straight pipe preceding the orifice. The orifice, of course, may be smaller than one-third pipe diameter without any effect. It is probable that the coefficient does not differ greatly from 0.99, even if the orifice is but one-half of pipe diameter. In all such cases, the effect of the varying velocity at different radii in the pipe is not transmitted through the orifice, and the discharge jet has the same velocity at all points, except at a narrow band close to the edge. For cases where the orifice diameter is greater than about one-half pipe diameter, it is probable that the variation of pipe velocity has some effect on the discharge jet.

The impact tube, as here discussed, can only be used with continuous flow, such as is given by centrifugal machinery. Pulsating flow, such as is given by reciprocating machinery, can not be integrated by the impact tube.

In order to compute the quantity or flow, it is also necessary to know the temperature in the pipe preceding the jet. This must be secured by the insertion of a thermometer through the pipe wall. However, as already pointed out, a practically identical reading will be given by a thermometer inserted in the jet outside the orifice. In all cases, for accurate work, the bare bulb of the thermometer should be in the jet, and wells or metal casings should be avoided.

The above methods have been used for measurement of many million cubic feet of air discharged by various types and sizes of fan blowers and centrifugal air compressors in the Lynn Works of the General Electric Co., since 1904. Fig. 18 shows some of the orifices which have been used.

ADVANTAGES OF THE ORIFICE METHOD

If a machine whose flow is to be measured can be arranged so that its discharge can be wasted, the use of an orifice in the discharge pipe is the only method of flow measurement which should be considered. The reason is that nearly the entire pressure rise produced by the machine can be utilized in causing discharge through the orifice. This gives a reading of such magnitude that accurate observations can be made. For instance, if the machine being tested gives an air pressure of 15 lb. per sq. in., the reading from which the flow is computed will be about 30 in. of mercury. If the machine gives an air pressure of about 1 lb. per sq. in., the reading will be 27 in. of water. Such magnitudes are easily measured and do not require the use of inclined gages, hook gages, or other means of getting small differentials.

The use of the impact tube gives the advantages of simplicity of formula in connection with initial velocity head, and ease of proper arrangement, over the use of a static hole in the pipe wall preceding the orifice.

VALUATION PAPERS

THE Valuation Session of the Annual Meeting will be devoted to a discussion of engineers' ideas of principles and methods in the valuation of industrial properties. The Committee on Meetings hopes that the information brought out will form a valuable supplement to the large amount of material already available on the subject of economic theories of values and their application to public utilities.

PRODUCTIVE CAPACITY A MEASURE OF VALUE OF AN INDUSTRIAL PROPERTY

By H. L. GANTT, NEW YORK, N. Y.

Member of the Society

SOME months ago a professor of political economy in one of our most conservative universities admitted to me that the economists had been obliged to modify many of their views since the outbreak of the European war. My comment was, that the professors of political economy were not the only people who had been obliged to modify their economic and industrial views.

The war has taught everybody something. Military methods have undergone radical changes, but industrial methods are undergoing changes which promise to be even more radical than the military developments have been.

If there is any one thing which has been made clear by the war it is that the most important asset which either a man or nation can have is the ABILITY TO DO THINGS. Our industrial and economical developments have in the past been largely based on the theory that the most important quality a man can possess is his *ability to buy things;* but the war has distinctly shown that this quality is secondary to the *ability to do things.* The recognition of this fact is having a most far-reaching effect, for it makes clear that the real assets of a nation are properly equipped industries and men trained to operate them efficiently. The money which has been spent on an industrial property, whether it has been spent wisely or unwisely, and the amount of money needed to reproduce it are both secondary in importance to the *ability of that plant to accomplish the object for which it was constructed,* and hence cannot be given the first place in determining the value of the property.

Inasmuch as every industrial plant is built to produce some article of commerce at a cost which will enable it to compete with other producers, the value of a plant as a producing unit must depend upon its ability to accomplish the object for which it was created.

To determine the value of an industrial property, therefore, we must be able to know with accuracy the cost at which it

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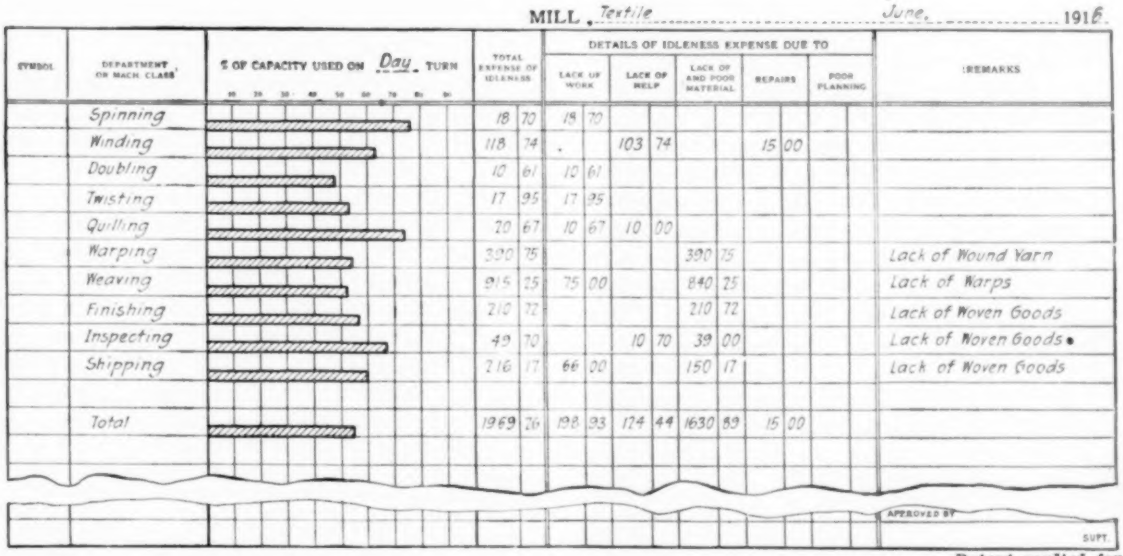
can produce its product, and the amount it can produce. To compare two factories on this basis, their cost systems must be alike; for, if there is a lack of agreement as to methods of cost accounting, there will necessarily be a lack of agreement as to the estimated value of the properties. There are many methods of cost accounting; but there are only two leading theories as to what cost consists of. They are:

First, that the cost of an article must include all of the expense incurred in producing it, whether such expense actually contributed to the desired end or not.

Second, that the cost of an article should include only those expenses actually needed for its production, and any other expenses incurred by the producers for any reason whatever must be charged to some other account.

The first theory would charge the expense of maintaining in idleness that portion of a plant which was not in use to the cost of the product made in that portion of the plant which was in operation; while the second theory would demand that such expense be a deduction from profits. When plants are operated at their full capacity, both theories give the same cost. When, however, they are operated at less than their full capacity, the expense of carrying the idle machinery is, under the first theory, included in the cost of the product, making the cost greater; while under the second theory, this expense of idle machinery is carried in a separate account and deducted from the profits, leaving the cost constant. It is most interesting to note that, *when costs are figured on the second basis, great activity immediately ensues to determine why machinery is idle, and to see what can be done to put it in operation.* It is realized at once that this machinery had better be operated, even if no profits are obtained from its operation and only the expense, or even part of the expense, of maintaining that machinery is earned.

Fig. 1 illustrates this subject most clearly, and is an indication of the efficiency of the management as contrasted with that of the workmen, about which we hear so much. It is interesting to note that charts of this nature, which are being made monthly in several large plants, have already had a very educational influence on the managers of those plants. They show that idle machinery which cannot be used should be disposed of, and the money received, and the space occupied, put to some useful purpose.


MILL Textile June, 1916

SYMBOL	DEPARTMENT OR MACH. CLASS	% OF CAPACITY USED ON Day TURN	TOTAL EXPENSE OF IDLENESS	DETAILS OF IDLENESS EXPENSE DUE TO: LACK OF WORK	LACK OF HELP	LACK OF AND POOR MATERIAL	REPAIRS	POOR PLANNING	REMARKS
	Spinning		18 70	18 70					
	Winding		118 74		103 74		15 00		
	Doubling		10 61	10 61					
	Twisting		17 95	17 95					
	Quilling		20 67	10 67	10 00				
	Warping		390 75			390 75			Lack of Wound Yarn
	Weaving		915 25	75 00		840 25			Lack of Warps
	Finishing		210 72			210 72			Lack of Woven Goods
	Inspecting		49 70		10 70	39 00			Lack of Woven Goods
	Shipping		216 17	66 00		150 17			Lack of Woven Goods
	Total		1969 26	198 93	124 44	1630 89	15 00		

APPROVED BY
SUPT.

Patent applied for

FIG. 1 IDLENESS EXPENSE CHART

A little consideration of the method of getting the data on this chart will make its value more apparent. It is a logical outgrowth of the paper I read at the Buffalo meeting on The Relation Between Production and Costs,[1] and is based on the fact that simple ownership of a machine costs money, inasmuch as it takes away from available assets. For instance, if we buy a machine for $1000 we lose the interest on that $1000, say at 5 per cent per year, then we have taxes on that machine at 2 per cent and insurance of 1 per cent. Further, the machine probably depreciates at a rate of 20 per cent per year, and we must pay $50 or more per year for the rent of the space it occupies. All these expenses, together $330, go on whether we use the machine or not. Thus, the simple fact of our having bought this machine and kept it takes from our available assets approximately one dollar per day.

If now the cause for idleness is ascertained each day we can find the expense of each cause of idleness as shown on the chart. That part which is due to lack of orders points out that our selling policy is wrong, or that the plant is larger than it should be—in other words, that somebody in building the plant has overestimated the demand. It is clear, however, that no conclusion should be based on the figures for one month, but on the results for a series of months during which the problem has been carefully studied. If a mistake has been made in building too large a plant, an effort should be made to determine the proper disposal, or utilization, of the excess in order that the expense of idleness may be taken care of, even if no profit can be made.

The next column shows the expense due to a lack of help, which means that we must investigate the labor policy.

The next column, showing the expense due to lack of, or poor, material, is an indication of the efficiency of the purchasing policy and storekeeping system. The next column reflects the repair and maintenance department.

If in any case the expense of idleness is greater than can be attributed to all of these causes together, it must go in the last column as poor planning.

[1] Trans. Am.Soc.M.E. vol. 37, p. 109.

We can hardly claim that such a chart gives us a *measure* of the efficiency with which the above functions are performed, but it certainly does give us an *indication* of that efficiency.

In several cases, the first of such charts gotten out resulted in the scrapping of machinery which had been idle for years. The space thus saved was used for a purpose for which the superintendent had felt he needed a new building.

In another case it resulted in the renting of temporarily idle machinery at a rate which went far toward covering the expense of carrying that machinery.

Under the first system of cost accounting the facts brought out by this method are not available, and the increased cost that a reduced output must bear is a great source of confusion to the salesman. The newer system, with its constant cost, shows that non-producing machinery is a handicap to the industry of a company, just as workmen who do not serve some useful purpose in a plant, or industry, are a handicap to that plant or industry. *Similarly, plants or people, therefore, who do not serve some useful purpose to a community are a handicap to that community, for idle plants represent idle capital, and idle people are not producers, but consumers only.* The warring nations have recognized these facts, and put both idle plants and idle people to work wherever possible.

The statements so far made concern principally the operation of industrial plants and the production of articles of commerce; but they are none the less true concerning the construction of industrial plants.

We may ask the same question about construction that we ask about operation; for instance, should the cost of a railroad include all the money spent by the people engaged in building it, or should it include only such money as contributed to the building of the road? As an illustration, is the cost of a piece of road which was built and then abandoned for a superior route a part of the cost of the railroad built, or is it an expense due to improper judgment on the part of the builders?

I am not discussing the question as to whether the public should be called upon to pay interest on the money uselessly spent through improper judgment, but I do think that *in all construction it should be possible to separate those expenses which contributed to the desired result from those which did not so contribute.* A comparison of these amounts will give a measure of the efficiency of the builders. On this knowledge proper action can ultimately be taken.

Still another factor enters into the value of a "going plant." We all have known cases where the same plant operated under one manager was a failure, and under another a very decided success. The value of a going plant, therefore, consists of two elements, namely, the value of the physical real estate and equipment, and the value of the organization operating it. In considering the value of an organization we should realize that it lies not so much in the personality of the managers or leaders (who may die or go elsewhere) as in the permanent results of their *training and methods, which should go on with the business,* and are therefore an asset and not an accident.

We have the authority of no less a person than Andrew Carnegie, Hon.Mem.Am.Soc.M.E., for the statement that his organizations were of more value to him than his plants. Before we can determine exactly the value of a going plant, therefore, we must find some means of measuring the value of the organization which operates it, for this is an integral factor in the valuation of an industrial property, which is just as real as the more tangible brick and mortar of which buildings are composed.

Our charts showing the expense of idleness give us at least a rough indication of this value, for they show the expense of inefficient management.

If the above premises are correct, the following factors are important elements in determining the value of an industrial property:

The cost of the product
The capacity of the plant
The portion of the plant operated, and
The expense of maintenance of the idle portion.

ACCURATE APPRAISALS BY SHORT METHODS

By JOHN G. MORSE,[1] BOSTON, MASS.

Non-Member

As the Factory Mutual Companies developed their methods of making plans and inspections and their tests of fire-preventing appliances, to the complete forms in use today, so also did they develop the making of insurance appraisals. At present these consist of inventories in as much detail as necessary to determine accurate values, while a system has been adopted for obtaining a reasonable estimate of all the minor items without going into elaborate detail. These appraisals are made without cost to the assured and have been appreciated to such an extent that they are constantly used as a basis for bookkeeping and cost systems, for mergers and other business uses.

In explaining this method by which a large manufacturing plant can be accurately appraised in a short time and with a comparatively small amount of work, I shall endeavor to show how useless it is to waste time on more laborious detail. No appraisal can be made without incorporating many figures that are based simply on estimate. It is, therefore, needless to carry the detail in any direction where it will not add to the accuracy of the final result.

Disregarding new factories, where records of actual cost are easily available, let us consider an older plant and particularly one where no records of cost have been preserved. A building may be measured so carefully that the exact amount of each material is known. The market price of each material may be obtained. Yet the amount of waste must be estimated and the amount for labor and all contingent expenses must be estimated.

The inventory of machinery may be made to the last trifling detail, yet the exact value can be obtained only for standard machines. Every special machine, as well as the cost for erecting every machine, must be estimated. Constant changes in market values always affect the accuracy of the result, but, aside from that, the amount of depreciation on both buildings and machinery must be estimated (or largely guessed at) before the actual present value is found.

A METHOD OF APPROXIMATION

The method developed by the appraisal department of the Factory Mutual Companies is based entirely on the theory that if the larger factories are carefully appraised, the less important items may be estimated in groups.

[1]Appraiser, Insp. Dept., Assoc. Factory Mutual Fire Ins. Cos.

For presentation at the Annual Meeting of The American Society of Mechanical Engineers, New York, December 5 to 8, 1916. The paper is here printed in abstract form, and advance copies of the complete paper may be obtained gratis upon application. All papers are subject to revision.

The property to be appraised is divided into two parts—buildings and machinery. The buildings are considered as empty structures, and anything that can be removed without altering the building is classed under machinery. In insurance appraisals, foundations and other underground work are ignored, but the method would be practically the same were they included. Machinery is divided into machines proper, shafting, belting, piping, electric wiring and furniture and miscellaneous apparatus. Special small tools, dies, patterns, drawings, molds, lasts and any objects of similar nature that exist in large quantities in the plant under consideration, are treated independently. The subject "miscellaneous apparatus" covers all objects of minor value not easily classified under any of the other heads.

The price values used for buildings and all the subdivisions of machinery are based on *replacing new at today's market* (regardless of original cost), and these price values are then depreciated as judgment dictates.

BUILDINGS

In appraising we use the square foot of floor area as a basis. Many architects and engineers use a factor based on the cubic foot of contents, but it is floor area that gives manufacturing facility, and the figures thus obtained are also useful in other parts of the appraisal, as will be shown later. As a groundwork we use the tables prepared by Charles T. Main, Mem. Am.Soc.M.E. These must, of course, be changed for different heights of stud, degrees of finish, thickness of walls, etc., and also for constant fluctuations in the market value of labor and materials. As new factors are obtained for reinforced concrete and other modern forms of construction, the tables form a guide for consistency as lengths and widths vary.

It is in appraising buildings that the uselessness of extended detail is strikingly apparent. Suppose two identical buildings are constructed, one by the highest bidder and one by the lowest. They may be more than ten thousand dollars apart. Is the actual cost of either a fair appraisal figure? An estimate based on the square foot of floor area that showed a figure halfway between the extremes would give a much more reasonable value. Indeed, Mr. Main states that several contractors have told him that they use his tables as a check before submitting bids.

The actual cost of foundations is far more unsafe to use for appraisal purposes. A building resting on extremely expensive foundations in quicksand is worth no more than a duplicate building resting on a ledge. A fair estimate for the cost of sufficient foundations in average ground would be a better figure to use for either when appraising an industrial property. With appraisals of public service corporations conditions are different, but that comparison is not to be discussed here.

MACHINES

It is our custom to make a complete inventory of all fixed machines, not only producing machines but those used for power and for maintenance. This inventory also includes all elevators and cranes. There is no hard and fast rule, but the practice is to list everything (exclusive of furniture, small tools, etc.) that has enough value to be worth considering separately. In making this inventory, the shortest description that will identify a machine is used. As an example, for a cotton spinning frame, "one ring frame 256 sp. 3″ met. bds. sep." means a ring frame with 256 spindles 3-in. gage, with metallic thread boards and separators. "One engine lathe 14 × 6 comp. taper" means an engine lathe with 14-in. swing, 6-ft. bed over all, screw cutting, without special gearing, with compound rest and taper attachment. Other special features that materially affect the cost are, of course, noted. In each case the above brief notes are all that are necessary to determine the value of the machine in question. By adhering to this method the fixed machines in a large factory can be inventoried in a much shorter time than would be deemed sufficient by one not acquainted with the work.

Having completed the inventory, it is a simple matter to appraise standard machines either directly from price lists or from data compiled from individual quotations and actual costs obtained when making other appraisals. Of course, all such prices are given in confidence and are used without the source of the information being divulged. In the same way machines built on order or by the owner can be appraised as data on similar machines accumulate. Allowance is made in all cases for the cost of freight, cartage and labor of erection. It should be understood that no prices are fixed arbitrarily by the appraiser. On the contrary, the figures are discussed with the owner or manager and as much assistance as possible obtained from their records.

APPROXIMATION ON MINOR ITEMS

The appraisal of buildings and machines forms the most important part of the work, both in time consumed and in results obtained. It would, therefore, be inconsistent to devote a greater amount of effort to the smaller part of the value. It is here that accurate "short cut" methods have been developed in the appraisal department of the Factory Mutuals.

Shafting. By figuring in detail representative lines of shafting, with couplings, hangers and pulleys included, various factors per lineal foot erected have been obtained. Experience soon teaches which factor to apply when examining lines of shafting in actual use. Opportunities are repeatedly presenting themselves to compare the results obtained with those of a detailed appraisal, and the accuracy of the approximate method is confirmed.

Belting. The most satisfactory method by which belting may be rapidly inventoried is to measure the main belts by eye. The machine belts can then be classified in groups, as similar machines will require about the same amount of belting. Individual motor drives are lessening the amount of belting in a modern factory, and where the machines are scattered and the belts vary greatly, it is usually easier to list them by using eye measurement than to attempt to apply any shorter method.

Piping. A detailed inventory of piping and pipe fittings would require an amount of time out of all proportion to that devoted to the remainder of the work. To obtain a "short cut" method has not been easy, due to the great variety in the material to be considered, much of which is hidden. The different uses to which the piping is put enable the appraiser to divide the subject into classes and these classes can be treated by different methods.

Automatic sprinkler piping can be appraised at a price per sprinkler head or, by what amounts to the same thing, by a price per square foot of sprinkled floor area. This applies to the piping inside the buildings only.

Steam heating, where consistent throughout the plant, can also be appraised on a floor area basis. Where the amount

of steam heat varies a price per lineal foot of coil or per radiator can be easily ascertained. The heating pipe in dry rooms, lumber dry kilns, paper dry lofts, etc., can be treated similarly.

Gas lighting can be appraised at a price per light. Where a building has gas lights at frequent intervals, a factor per square foot of floor area can easily be estimated.

The piping used for manufacturing purposes presents the greatest difficulty. The steam and water pipe in a steam power plant will vary little from a standard figure per horsepower of boiler rating. For long runs of covered steam pipe through rooms where there are few or no outlets, a price per lineal foot can be used.

In plants where there is a great quantity of piping, particularly in bleacheries and paper mills, small factors cross-checked by large factors can be used. These factors are obtained from time to time when actual costs in a new plant are available. In all cases the large factor for steam is based on the horsepower rating of the boiler plant. In a bleachery the large factor for water is based on the number of kiers; in pulp and paper mills, for water and stock piping, on the number of pulp grinders, digesters, wet machines and paper machines, as the case may be. The small factors in all cases are varied with the pieces of apparatus. By using both methods in estimating a plant a sufficiently accurate total can be obtained. With factories making dyes, chemicals, soaps, etc., the same method can be employed.

Air piping, though quite extensive in modern machine shops, never amounts to more than a very small fraction of the value of the plant. The runs of pipe are easily followed and a factor per lineal foot or per machine supplied can be ascertained.

Fuel-oil and gas or gasoline piping is of still less importance from a value standpoint and can be easily estimated in a manner similar to that used with air piping.

Furniture and Apparatus. In every plant there is a large amount of equipment (exclusive of small tools, dies, etc., which will be considered later) that cannot be classified under the head of machines and yet does not belong to any special class. This equipment is covered under the very elastic term "furniture and apparatus." All furniture, benches, racks, trucks and scales come under this heading. In a textile mill all bobbins, spools, etc., in a metal-working plant all boxes, trays and cans, indeed, every miscellaneous article that cannot be included under any other definite title, can be covered under this.

To list all of these items in detail would be arduous. Many would be destroyed and new ones added before the list could be completed. The value, however, would be insignificant when compared with the total value of the plant. It is not difficult, however, to obtain a fairly accurate estimate.

In a cotton mill a factor per spindle can be used, and in a woolen mill a factor per set of cards. In any textile mill, however, it is possible to obtain from the different foremen the approximate number of bobbins, spools, roving cans, filling boxes and trucks, while the appraiser can easily estimate, room by room, the value of what other miscellaneous apparatus there is. In a metal-working plant the benches and racks can be appraised by a factor per lineal foot; the number of tote boxes, cans and trucks can be obtained from the foremen, and the other miscellany can be estimated as above. A similar method can be applied to any plant. Office furniture can be appraised, without listing, by using judgment.

Small Tools and Dies. All machine shops contain an equipment of small tools and all metal-working plants an equipment of dies. The proportion that the value of these bears to the value of the whole varies greatly with the class of work. In many concerns fairly accurate records are kept of the cost of such small tools and dies. Experience has shown that factors per producing machine can be used that will give a fairly accurate appraisal. Where a closer estimate is needed, the tool and die storerooms can be examined and fairly representative shelves or drawers can be appraised to obtain a factor or factors to be used for the remainder.

Patterns and Drawings. Depreciation plays an important part in finally determining the value of patterns and drawings. To obtain the new value of patterns it may be possible to study the pattern-shop pay roll for a given period and add a proper amount of overhead expense. So many patterns are obtained from outside, however, that the most satisfactory method is to examine the shelves in the pattern storage, classify them into a few groups and estimate a price per square foot of shelf area for each group.

With drawings the pay roll, plus overhead expense covering the entire time since the drawings began to accumulate, gives the most accurate basis. For replacing cost the present rates of pay should be used, but a deduction should be made for time spent in experimental work in either case. A good cross-check is to obtain from the head draftsman the total number of drawings, divided into several groups for size and cost.

Molds, Lasts, etc. Molds, used both for hard and soft rubber and in several other classes of manufacture, are usually carried on accurate inventory by the owner, but if not, they can be appraised by methods similar to those used for small tools and dies. Lasts in shoe factories, copper shells in print works, print rolls in wallpaper factories and dandy rolls in paper mills are almost invariably carried on inventory. In the rare cases where not so listed they can be easily counted, divided into classes and an average price to be used for each class readily obtained.

Miscellaneous. The above-mentioned subjects are the ones most commonly found. Occasionally the appraiser visits a manufacturing establishment which is out of the ordinary and special auxiliary apparatus is found in large quantity. By using some of the methods described for appraising small tools, patterns, etc., the value of these extras can be obtained.

Stocks and Supplies. In making insurance valuations the Factory Mutual appraisal department almost invariably relies on the inventories of the assured to obtain the value of stock and supplies. In rare instances, however, where such are not obtainable, a rough average obtained from previous appraisals of similar plants can be used.

ROUGH APPROXIMATION

The methods described above enable the appraiser to make an accurate estimate of the value of buildings and machinery in a much shorter time than would be used were all items listed in detail. To obtain quickly an approximate valuation a comparison can be made with other appraisals on a basis of the square foot of floor area or of the number of producing machines. In specific instances the comparison can be made per spindle, per set of cards, per kier or per paper machine.

DEPRECIATION

There is a wide difference of opinion as to the amount of depreciation that should be allowed on buildings and various classes of machinery and as to the method of caring for such

depreciation in the book accounts. Indeed, another argument in favor of the "short cut" method of making valuations is the fact that two competent appraisers would show more difference in the value of a plant on account of varying opinions as to the amount of depreciation to be allowed than in errors made in estimating the new value.

Depreciation for Insurance. A building that houses a going concern or a machine that is turning out a salable product deserves less depreciation from an insurance standpoint than from any other. It is the intention of the Factory Mutual Insurance Companies to deduct for depreciation what judgment shows is deserved for actual wear and tear and for obsolescence. The methods used in estimating this depreciation vary with buildings and with different kinds of machinery. In some cases a sliding scale can be applied and in others an average figure.

Depreciation of Buildings. A building badly out of repair naturally deserves fairly heavy depreciation. A building in good repair, but so antiquated in size and shape that it is manifestly unsuited for the uses to which it is being put, also deserves a reasonably heavy deduction. When, however, a building is of such dimensions that it perfectly answers its purpose, has remained plumb and is constantly kept in repair, actual age has little influence on judgment. It is considered that about five per cent of the new value is enough. In other words, buildings are not depreciated a certain per cent a year, but have a flat amount deducted on account of condition and not on account of age.

Depreciation of Machinery. Machines vary greatly both in the manner in which they wear out and in the rapidity with which they go out of date. In rare cases where a machine has been practically superseded in the market by one that will cost much less, it is better to use for a new value the cost of the less expensive machine rather than show an excessive depreciation. As a rule, the amount deducted applies chiefly to wear.

With machines that need repairs at all points from time to time, a day arrives after a period of years when it is better to throw them out altogether and replace with new rather than continue to repair them. Practically all textile machines come in this class, as do engines and other power-plant machines, and also some machine tools, wood-working and paper-working machines. To all of that nature a depreciation table is applied, allowing 2, 2½, 3, 4 or 5 per cent a year, deducted from the net and not from the gross. If a machine is entirely rebuilt it is usually considered to be worth at that time within five per cent of new value, and the table is applied for succeeding years. In either case, the probable average life is ascertained and the table that best fits is used, but seldom is the depreciation carried to a point beyond fifty per cent.

There are many kinds of machines where the main portion, sometimes as much as eighty per cent of the total value, remains for years with practically no wear. The small moving parts, however, wear so rapidly that they are constantly being replaced. This is true of a great variety of machine tools, metal-, wood- and paper-working machines. With these it is considered that the wearing parts are always in a state of fifty per cent depreciation, and the amount deducted is half of the percentage the value of the wearing parts bears to the total value of the machine. This method also applies to rolling mills, rubber mills and calenders where the frames and gearing remain intact for years and the rolls constantly wear down and are replaced.

There is another class where neither the depreciation table nor the definite average described above can be used. This includes most of the machinery in paper mills, bleacheries and dye works where wet processes are used. These machines wear rapidly and are frequently rebuilt. Paper machines in particular are composed of a train of parts, and from time to time different sections are either rebuilt or removed entirely and replaced. The depreciation in such cases depends upon the condition at the time of the appraisal and is not influenced by the age of what remains of the original machine.

Depreciation of Shafting, etc. It is quite apparent that to obtain the age of shafting, belting, piping, etc., would nearly always be impossible, so that general figures for depreciation are safest. Shafting shows such slight wear that depreciation is seldom recognized. It is becoming the custom, however, to show either a slight deduction or else purposely record the new value at a conservative figure when on account of poor arrangement an amount in excess of what is needed is in use.

Main belts wear slowly, while machine belts will always average 50 per cent wear, so that, as a rule, the total amount of belting is depreciated 33⅓ per cent.

Piping will last for years, except where exposed to acid fumes. Pipe covering and valves show wear, but piping as a whole is seldom depreciated more than ten per cent.

The miscellaneous equipment classed under the head of "furniture and apparatus" is made up of objects most of which are constantly wearing out. The amount is, therefore, usually depreciated from twenty to fifty per cent.

Small tools, dies, print rolls and electrotypes wear out, but they are affected to a great extent by obsolescence. Patterns, drawings, molds and lasts are subject to depreciation for the latter reason only. In determining the amount to be deducted from the new value of any of these the appraiser must ascertain what proportion of the equipment is indispensable or practically new.

APPRAISAL COMPANIES

Having explained the method by which an accurate appraisal can be made, expending the minimum amount of time, the writer may well refer briefly to the method of making an appraisal by laborious, painstaking detail, best illustrated by the work of the appraisal companies. The finely prepared volumes are found to contain a list of substantially everything on the premises. They are overburdened with extended descriptions of buildings and machinery, far more than is necessary to determine value and decidedly confusing to the searcher for individual items. The usual proportion of the total value recorded is based on estimate only, and invariably there are errors large enough to counterbalance whole pages of minor items so carefully noted. The law of averages usually balances these errors, so that the final result is approximately correct, but no more so than that of an appraisal made by the shorter method already described.

CONCLUSION

This so-called approximate or "short cut" method of making appraisals has been employed by the Factory Mutuals for years and foundations and other uninsurable properties are omitted, while the depreciation charged off is for insurance purposes only. It should be emphasized that the figures thus obtained are not intended for other uses, though safe enough for proportioning a cost system. But the method described can be employed in making an appraisal for any purpose.

RAILROAD PAPERS

THE Sub-Committee on Railroads has been fortunate this year in securing for presentation and discussion at the Annual Meeting papers of interest both to locomotive engineers and to passenger-car men. The session in charge of this committee will therefore be of wide interest.

MECHANICAL DESIGN OF ELECTRIC LOCOMOTIVES

By A. F. BATCHELDER, SCHENECTADY, N. Y.

Member of the Society

IMPORTANT features in the mechanical design of electric locomotives are, in the order of their importance:

1 Safety of operation
2 Adaptability to service conditions
3 Reliability in service
4 Convenience of arrangement as affecting safety and efficiency of operation
5 Power efficiency (affected by mechanical design)
6 Service time factor (ratio, time available for service to total time)
7 Cost of maintenance of permanent way
8 Cost of maintenance of locomotives
9 First cost.

SAFETY OF OPERATION

The steam locomotive has been developed to such a state of perfection that it can operate at near 80 m.p.h. with perfect safety; but no one would think of operating at this speed backwards. With the coming of the electric locomotive, the railroad operator is not content with single-end operation, but must have a locomotive that will operate equally well in either direction. This does not impose any serious difficulties in the design of locomotives for speeds under 50 m.p.h., but for higher speeds it requires very careful consideration of running-gear details, to obtain the most satisfactory results as to tracking and effect on rails and roadbed.

The steam locomotive has what now seem to be natural characteristics to allow high-speed operation in one direction. These characteristics are low center of gravity at the front end carried on the center pin of a 2-axle guiding truck tending to prevent rolling over and having but little effect on the guiding, and high center of gravity at the rear end with inside journal bearings allowing the locomotive to roll and increasing the time element, which thus reduces and distributes the lateral pressure against the rail over a longer distance and increases the vertical pressure on the rail, thus holding the locomotive more firmly in place. These same characteristics can be obtained in electric locomotives by the sacrifice of double-end operation.

The advantages gained in operating the electric locomotive in either direction are so important that means should be provided for satisfactory double-end operation. One way of doing this is by using a 4-wheel guiding truck at each end of the locomotive. With the use of the extra truck, however, the importance of a high center of gravity largely disappears. The lateral pressure against the rail at the rear end now appears at the truck flanges rather than at the flanges of the driving wheels, and the high center of gravity no longer provides the same increased vertical pressure on the outer rail at the point of the maximum lateral pressure. The lateral stresses from guiding the main frame being taken at the center pin of the two guiding trucks, the additional vertical pressure on the outer rail is dependent upon the height of these center pins rather than upon the height of the center of gravity of the main frame above the wheel hubs, thus leaving less advantage to be derived from a high center of gravity.

The paper shows that while the swivel truck is desirable as a guiding agent at the front end, it is not so desirable at the rear end, and means must be provided to prevent oscillation of the truck and to accomplish the same results as the high center of gravity in a single-end locomotive. For this it is necessary to reduce the momentum effect and to reproduce the equivalent of the time-element factor and of increase of vertical pressure on the outer rail that is characteristic of the high-center-of-gravity single-end locomotive.

The momentum effect can be reduced by introducing resistance against swiveling, thus restricting the truck from oscillating from one side to the other of the track. The amount of this resistance is determined by the allowable amount that can safely be applied to the truck when leading. To reproduce the time-element factor, lateral movement can be given to the truck center pin by any of the several methods for giving lateral movement to the leading truck center pins on locomotives. However, the writer has obtained the best results with the method that is the nearest to constant pressure and dead beat, as it also tends to prevent oscillating.

To increase the vertical pressure on the outer rail, the center bearing of the truck can be made wide, thus allowing the vertical component of the lateral pressure at the center of gravity to be transferred through the bearing to the wheel, or, with the narrow center bearing, the height may be made such that the lateral pressure at that point will result in an increased vertical component independent of the height of the center of gravity.

It is the writer's opinion that the double-end locomotive, while its characteristics are different, can be designed for high speed with safety equal to the single-end locomotive, and this regardless of the height of the center of gravity.

ADAPTABILITY TO SERVICE CONDITIONS

The electric locomotive, besides being required to operate in either direction, is often also required to be adapted for operating high-speed passenger trains and heavy low-speed freight trains over main-line tracks, to negotiate sharp curves, and to be easy on light track and bridge structures.

With locomotives having geared motors, the requirement of operating the passenger and freight trains can often be met by changing the gearing to obtain the proper speed and drawbar pull.

The running gear can be made with trucks of short wheel base and coupled together, the number of trucks depending upon the required weight of the locomotive for its maximum drawbar pull, and also on the allowable weight per axle.

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With such a design curves of very short radius can be operated over, and the weight per axle can be such as to allow operation over light structures.

RELIABILITY IN SERVICE

When the design is such that it is safe to operate at the required speeds and is proper for the curves and other service requirements, and liberal factor of safety is provided for the parts subjected to strain, reliability in service affected by the mechanical part of the locomotive depends mainly upon the bearings, their lubrication, and the method of power transmission from the motors to the drivers. It is necessary therefore to provide effective lubrication and as few bearings and as simple driving mechanism as the design of the motors will allow.

CONVENIENCE OF ARRANGEMENT AS AFFECTING SAFETY AND EFFICIENCY OF OPERATION

After providing all the safety appliances recommended by the Interstate Commerce Commission, it is important to arrange for the most convenient location of the operator to allow him an unobstructed view of the track and signals, to place within his easy reach the air-brake valve and locomotive-signal-device handles, as well as the reverse and power-controller handles, keeping in mind the importance of making them so free from complication that the operator will require the least amount of thought to manipulate any of the devices and be left free to respond to signals and look out for emergencies.

The arrangement for housing the electrical apparatus and its position in the cab must be governed largely by its design, but it is important to arrange it so that its operating parts are accessible and easy to inspect, and at the same time are protected against persons coming in contact with any live parts.

POWER EFFICIENCY

The power efficiency as affected by mechanical design is governed largely by the type of traction motors. It is apparent that the gearless motor mounted directly on the axle allows the design of maximum efficiency on account of its few bearings and absence of gearing and moving parts. The gearless motor mounted on a quill and driving through springs to the wheels may be considered second in its possibilities for high-efficiency design, it having additional bearings and a greater number of moving parts. The single-reduction geared motor with its additional bearings and gear losses can be given third place in efficiency design; the single-reduction geared motor driving through gears and side rods to the wheels may be placed fourth, and the gearless motor driving through side rods and jackshaft to the wheels fifth.

SERVICE TIME FACTOR

The service time factor is dependent upon the ability of the locomotive to operate under all service conditions and without undue strains, which requires a liberal design of its wearing parts. In addition to this it depends on the simplicity of design of the locomotive and the ease with which its parts can be inspected, adjusted, repaired, or replaced.

COST OF MAINTENANCE OF PERMANENT WAY

The cost of maintenance of permanent way can be increased or reduced by the design of the locomotive. The lowest cost is obtained when the locomotive meets its service requirements without undue strains, when the rotating parts are balanced, the weights per axle are suitable for the structures, a suitable equalizing system provided to maintain the proper weight distribution, and provision made to protect against flange wear.

COST OF MAINTENANCE OF LOCOMOTIVES

The cost of maintenance of the locomotive is dependent upon safety of operation, adaptability to service conditions, reliability, convenience of arrangement, and the same items that enter into its service time factor. It is also governed by the same conditions as affect the maintenance of permanent way.

The care with which the material is selected, the quality of workmanship, ease with which the parts can be inspected, adjusted, repaired or replaced, and simplicity of design govern maintenance cost.

FIRST COST

This will depend largely upon the design chosen, but its importance, except at the time of purchase, becomes of little moment when taking into consideration the eight foregoing features. With two locomotives designed for the same service, the cost of the difference in efficiency and locomotive maintenance alone for one year may, when capitalized, amounts to a considerable proportion of the first cost of one of the locomotives.

Too much importance cannot be given to developing to the utmost the mechanical part of the electric locomotive. From the present outlook, the locomotive for high-speed passenger service with gearless motor with armature mounted directly on the axle, and the locomotive for freight and switching service with single-reduction geared motor mounted on and geared to the axle, lend themselves best to simple design and low cost of maintenance.

In making these comments the writer does not criticize the work of any other designer. The conclusions he has reached are drawn from experience with his own designs of the various types referred to.

CLASP BRAKES FOR HEAVY PASSENGER EQUIPMENT CARS

By T. L. BURTON[1], ST. LOUIS, MO.

Non-Member

THE first requirements of a power brake are to stop the vehicle to which it is applied in the shortest possible distance, consistent with maximum rail adhesion, during emer-

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gency braking, and in the minimum distance, consistent with accuracy and smoothness, during service braking, all of which is largely dependent upon the type of equipment employed, the manner in which it may be operated and the braking ratio (percentage of brake power) that can be successfully used.

The braking requirements for present-day heavy steel passenger-car equipment can best be appreciated by a careful analysis of the records of a number of passenger-train brake tests with the earlier light wooden cars and the heavy steel equipment of today, and for those who care to make such an analysis the paper which was presented by S. W. Dudley at the February, 1914, meeting of the Society is unqualifiedly recommended. For ready reference, however, it might be interesting to state that in 1902 an exhaustive series of brake tests were made on the Pennsylvania Railroad, under the supervision of A. W. Gibbs, with trains consisting of one locomotive and comparatively light wooden cars, in which stops were made from a speed of 60 m.p.h. with emergency-brake applications in approximately 1000 ft.

In 1903 similar tests were made on the Central Railroad of New Jersey, under the writer's supervision, in which passenger trains consisting of what was then considered modern equipment were stopped from a speed of 60 m.p.h. in an average distance of 970 ft.

Early in 1905 another series of tests was made on the Pennsylvania Railroad with equipment similar in weight and construction to that used in the 1902 and 1903 tests, with substantially the same results.

The emergency braking ratio in the Pennsylvania Railroad and the Central Railroad of New Jersey tests did not exceed 125 per cent of the car weight, and a reducing mechanism was employed for automatically reducing the braking ratio during the stops, so that the mean effective ratio was approximately 100 per cent.

Based upon results obtained in the three brake tests just referred to, a distance of 1000 ft. was considered a desirable theoretical emergency stop from a speed of 60 m.p.h. for a passenger train having the ordinary "high-speed brake."

In the fall of 1905, closely following the second test of the Pennsylvania Railroad, similar tests were made on the New York Central Railroad, under the supervision of C. H. Quereau. The locomotive and cars used in this test weighed, however, considerably more than the ones used in previous tests, and the emergency stops from 60 m.p.h. were over 1200 ft., in cases where the air-brake equipment and braking ratio were substantially the same as had formerly produced approximately 1000-ft. stops with lighter equipment.

Results of the New York Central test immediately established the fact that as the weights of the individual vehicles of which the train was composed increased, the braking ratio would have to be increased if the length of the stop was to be no greater than was formerly made with lighter equipment, and to meet the requirements of the heavier locomotives and cars the air-brake manufacturers immediately developed an air-brake equipment with which could be had a higher braking ratio than was obtainable in previous tests with lighter locomotives and cars.

In 1908 another exhaustive series of tests was made on the Southern Pacific Railroad with still heavier locomotives and cars, in which it was found that a distance of over 1300 ft. was required for stopping the heavier trains from a speed of 60 m.p.h. with no greater emergency braking ratio than was formerly required for making a 1000-ft. stop with the ligher equipment.

In 1909, R. B. Kendig, Mem.Am.Soc.M.E., conducted still another brake test on the Lake Shore & Michigan Southern Railroad with trains consisting of locomotives and cars closely approximating present-day equipment in weight, for which was required an emergency braking ratio of 180 to 200 per cent of the car weight for producing approximately a 1200-ft. stop from a speed of 60 m.p.h. These tests demonstrated to the entire satisfaction of all who participated in them that the emergency braking ratio for heavy steel cars would have to be not less than 180 per cent of the car weight if the emergency stops were to be made in no greater distance than formerly required for the lighter cars.[1]

Realizing that 180 to 200 per cent braking power applied to one side of a car wheel would probably produce ill effects on journals, brasses, trucks, etc., the writer had made a careful and thorough analysis of the force action on car journals as effected by high-braking forces. These analyses show conclusively the undesirability of applying to one side of the wheel a braking ratio of sufficient magnitude for stopping the modern heavy steel equipment in no greater distance than formerly required for stopping the lighter wooden equipment. A summary of these analyses is given in the text of the paper and in illustrations.

In the light of these analyses, it is the writer's opinion that a suitable design and make of clasp brake should be used on modern steel passenger equipment, the advantages of which are, briefly stated, as follows:

SAFETY

a In case of danger, requiring an emergency brake application, a much shorter stop can be made with the clasp brake than with a single-shoe brake, other conditions except those affected by the brake gear being the same in both cases.

b If properly designed, manufactured and installed, there is no occasion to disconnect any part of the clasp-brake rigging between shopping of cars. The probability of the brake becoming inoperative through a failure to properly replace cotters when disconnecting the brake with the car in transit and the loss of brake pins resulting therefrom is reduced to a minimum.

c A thin brake shoe or the loss of a brake shoe does not in all cases necessitate cutting out a brake to save the brake beam.

d If the clasp brake is properly designed, manufactured and applied to the car it will be practically impossible to adjust the rigging so as to impair its efficiency or interfere in any way with its proper operation.

e The axles and truck frames, in addition to performing their usual functions, become safety hangers for the major portion of the brake rigging, thus reducing to a minimum the possibility of derailment that might be caused by brake rigging dropping on the track in case of failure of the truck brake gear.

f While the possibility of disconnected brake parts dropping on the track is greatly reduced in comparison with the single-shoe type of brake gear, the danger is further reduced on account of the clasp-brake parts being much lighter than those of the single-shoe type.

[1] It is not the intention to show by the above references to brake tests the distance in which trains may be stopped in service. In conducting brake tests variations in equipment by which stopping distances are effected are necessarily reduced to a minimum, otherwise the results would not be comparative. The stopping distances referred to should, therefore, be used only as a basis of comparison for different equipments, and it should not be assumed that such stops would be reproduced in actual train service. On the contrary, it may safely be assumed that the stops with service trains should be much longer than test records show.

ROUGH VS. SMOOTH TRAIN HANDLING, ACCURACY IN MAKING STOPS, ETC.

g Many modern passenger trains are, on account of the inherent shortcomings of the "single-shoe" type of brake, extremely difficult to handle smoothly. Careful investigation of the complaints of roughly handled passenger trains indicate that most of these troubles are due largely to non-uniform braking power and the *time in which it is developed,* as a result of improper piston travel.

In service braking at low speeds, whether for the purpose of stopping from such speeds or for completing stops from high speed, such as making a *second brake application* as the stopping point is approached, the brake power should be light and the retardation resulting therefrom must be developed slowly, or simultaneously on all cars, if smooth handling is to be insured. Smooth service stops from all speeds are also contingent upon the flexibility of the brakes.

The seriousness of slack-action shocks is greater than in former years on account of the greater average weight of cars and increased length of trains, and the chances for producing them are much greater with the single-shoe brake than was formerly the case with lighter cars and shorter trains.

Contrasting the desired rate at which the braking power should be developed at low speed, making service or emergency stops from high speed in a minimum distance necessitates developing a high nominal braking power, and in addition thereto it must be developed rapidly.

The rate at which both service and emergency braking power are developed is largely dependent upon piston travel, and with a view to producing the best results under all conditions, the automatic brake is built on the principle of maintaining, as near as practicable, 8 in. of piston travel at all times and under all conditions. As an example, if, during service braking at low train speeds, the piston travel resulting from a 10-lb. brake-pipe reduction is only 5 in. instead of 8 in. (with some brake riggings it is 5 in. or less), the braking power will be fully 100 per cent greater than with the predetermined standard piston travel of 8 in.; and with the shorter travel a 10- or 15-lb. reduction will practically equalize the auxiliary reservoir and brake cylinder pressure, thereby materially reducing the flexibility of the brake. While the vibration of the car may cause the 5-in. piston travel to increase to practically normal before the stop is completed, it will not do so except when stopping from high speed. Moreover, if the travel does increase before the stop is completed it will contribute nothing to smooth handling, as the shock will have occurred while the travel was short.

Other things being equal, the clasp brake will develop a higher percentage of braking power than the single-shoe brake during heavy service or emergency applications, but for light service braking at low speed the brake power developed from a given brake-pipe reduction is much less with the clasp brake than with the single-shoe brake, and it is developed at a much lower rate, thereby insuring smoother train handling than can be had with the single-shoe brake.

The results just cited are due to the fact that with the single-shoe brake the piston travel is practically proportional to the cylinder pressure developed, whereas with the clasp brake, with a shoe on each side of the wheel, the horizontal wheel or shoe movement relatively to the brake cylinder is reduced to a minimum, and such movement if produced from any cause will have no effect on the piston travel. Moreover, with the clasp brake the shoes are located sufficiently close to the horizontal center line of wheel centers to obviate the *pulling down* of truck frames and variations in piston travel resulting therefrom.

The removal of worn shoes and their replacement by a given number of new shoes without readjustment of slack, as is frequently done on long runs, will not affect the piston travel with the clasp type of brake to the same extent as would occur with the single-shoe type of brake.

The only remedy that can be offered for the difficulties arising from improper piston travel, which so seriously affects the braking power resulting from a given brake-pipe reduction and the rate at which it is developed, is to apply a truck-and-body brake gear that will substantially insure uniform piston travel under all conditions of speed and cylinder pressure. The use of the clasp type of braking rigging with body-brake gear to suit will, to a large extent, accomplish these results and restore the flexibility of brake operation which existed prior to the adoption of extremely heavy cars and long trains of the present day equipped with single-shoe brakes.

IMPROVES RIDING QUALITIES OF EQUIPMENT

h The high brake-shoe loads developed one one side of the wheels with a single-shoe brake produce a binding effect between pedestals and oil boxes which interferes with the proper action of the truck springs during an application of the brakes, and when the shoes are hung low, as is necessary with the ordinary six-wheel truck and single-shoe brake, the pulling-down effect of the truck defeats in many cases the purpose of the truck equalizing springs. This binding between pedestals and oil boxes and the increased load on truck springs causes the car to ride hard when brakes are applied. These evils do not exist with the clasp brake.

ELIMINATION OF HOT BOXES

i With the single-shoe type of brake rigging it will be observed that the high pressure exerted by the shoe on one side of the wheel causes the tilting of brasses sufficiently to lift one side of the brass a considerable distance away from the journal (see Figs. 3 and 4) so that a wide space is open for waste to be caught between the brass and the journal when the brake is released and the brasses and journals resume their normal position.

Investigation has shown that waste has been found wrapped around the journal, and that the collars on the axles are forced against the sides of the boxes. Further, these effects are not confined to emergency applications, but will also be noted in service applications of the brake and are all in the direction of producing hot boxes, while the unequal distribution of braking power and binding between boxes and pedestals has a tendency to cause slid flat wheels.

DECREASE IN MAINTENANCE COST AND BRAKE-SHOE COST

j While the principal advantages inherent in the clasp brake, of greater flexibility in service braking, etc., are outlined in the foregoing, and the primary consideration for its adoption must be the increased emergency efficiency over the single-shoe type of brake, providing as it does for the possibility of greatly shortened stops, with a lesser tendency to slide wheels, and consequent increase in safety, the clasp brake will also, due to the principles involved in its design and con-

struction, show a decided decrease in cost of maintenance, not only in the brake rigging itself, but a substantial decrease in the cost of brake-shoe material for equal amounts of energy dissipated.

COST OF TRAIN OPERATION

k Investigation has developed the fact that with the single-shoe type of brake on modern passenger equipment cars and the piston travel adjusted to proper limits, approximately 35 per cent of the available tractive effort of the locomotive was consumed in pulling the train against the effect of brake shoes dragging on the wheels with the brakes released.[1] With the clasp type of brake and the resulting increased shoe clearance, this loss is eliminated, leaving better maintenance of schedules and corresponding decreased cost of train operation.

CONCLUSION

l In considering the application of clasp *vs.* single-shoe brakes to the modern heavy steel passenger car of to-day, the *advantages* of the former over the latter, as enumerated above, are but secondary to the primary question to be settled, namely: Are the present-day trains to be stopped from given speeds in no greater distance than was required ten to fifteen years ago for stopping the lighter wooden cars? If so, the question of whether or not an efficient clasp brake should be used on such trains is conclusively settled.

The collision energy of the heavy steel passenger trains as compared to the lighter wooden train has increased directly in proportion to the increased weight, and in geometrical proportion to the increased speed, in cases where speeds have been increased, to say nothing of the increased density of traffic. It would, therefore, seem that the use of a clasp brake is essential in successfully controlling the speed of present-day or future passenger trains, and without regard to nominal increase in first cost or multiplicity of parts of brake gear resulting therefrom.

m The foregoing discussion on the relative performance of the clasp and single-shoe brake is with the distinct understanding that the former is designed upon a scientific engineering basis and is constructed and installed in accordance with the principles involved in the design; for while the claims made for the clasp type of brake have been conclusively demonstrated by exhaustive tests and road service, it has likewise been demonstrated that where the clasp brake is improperly designed or carelessly manufactured and installed the results obtained in service are in many respects less desirable than with the single-shoe brake.

[1] See M.C.B.Assn. Proceedings, 1910, page 97, paragraph 3.

GAS POWER PAPERS

THE Sub-Committee on Gas Power will have charge of a session at the Annual Meeting at which important papers on gas manufacture, gas analysis, comparison of steam and gas engines, internal combustion engines, and gas tractors will be presented. Two of the papers for this session appear below.

THE INTERNAL-COMBUSTION MOTOR FOR TRACTION ENGINES

BY A. A. POTTER, MANHATTAN, KAN.

Member of the Society

and

W. A. BUCK,[1] MANHATTAN, KAN.

Non-member

AT the present time, over one hundred manufacturing concerns in the United States are building traction engines driven by internal-combustion motors. The designs differ greatly: some have motors with horizontal cylinders, others with vertical cylinders. In some designs the power of the motor is delivered to one wheel, in others to two, and in still others to all four wheels; several designs are of the so-called "creeping grip" types.

The development of the traction engine for agricultural purposes has been along lines entirely different from those of the automobile. The early engines developed 60 to 80 h.p. on the brake and 30 to 40 h.p. on the drawbar; they were expensive, complicated, and unsuited for any but the largest farms of the country. The present tendencies of manufacturers are to build smaller engines and to standardize the product.

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OBJECT OF INVESTIGATION

The purpose of this investigation was to determine the fuel economy and thermal efficiency of a great variety of traction-engine designs, to find out the practicability of the fuels heavier than gasoline for traction engine use, and to compare the rating, valve setting, timing and other details of commercial traction engines. Particulars of the motors tested and of the fuels used are given in Table 1.

GENERAL CONCLUSIONS

From the results of this investigation the authors have derived the following general conclusions:

a The four-cylinder motor is better adapted for belt work on account of the greater number of impulses per revolution.

b The single-cylinder motor and the two-cylinder motor operate better than four-cylinder motors with fuels heavier than gasoline.

c Carburetors now used are satisfactory for gasoline, but a carburetor jacketed with heat from exhaust gases should be employed when operating with kerosene or with the heavier fuels.

d The ordinary automobile motor is too light for traction-engine work. The traction-engine motor should operate at lower piston speeds than the automobile motor. Motors operating at piston speeds of 700 to 900 ft. per min.

are giving satisfaction.

e The vertical types of motors are preferable on account of greater accessibility, longer lift and better balance.

f The valve-in-the-head type of motor has the more efficient plicity, is the best system of ignition for traction engines.

i The fuel-economy range is from about 1.30 lb. per shaft h.p. per hour at one-fourth load to about 0.7 lb. per hour at full load. The fuel consumption in lb. per shaft h.p.

TABLE 1 PARTICULARS OF THE TRACTION-ENGINE MOTORS TESTED AND THE FUELS USED

Engine	Type (all 4-stroke cycle)	Ignition System	Lubrication System	Carburetor	Cooling System	Governor	Fuel: Gasoline or Kerosene	Fuel: Specific gravity	Fuel: Heating Value, B. t. u. per lb.	Rating, b.h.p.	Bore, in.	Stroke, in.	Rev. per min.
A	hor., twin, 2-cyl.[1]	high-tension, magneto	mech. op. sight-feed oilers	....	pump	throttling[2]	K	0.809	19,700	60	...	...	...
B	(same motor as A, but	tested when new)		....	....	....	K	0.800	19,680	60	...	...	...
C	vert. L-head,[1] 4-cyl.	high-tension,[3]	splash & mech. op. sight feed	Bennett	pump	throttling[2]	G / K	0.739 / 0.786	19,670 / 19,500	65	7¼	9	500
D	vert., T-head, 4-cyl.[1]	high-tension[3]	sight-feed pump	Bennett	pump	diaphragm[4]	G	0.741	19,000	50	6	7	650
E	hor., opposed, 4-cyl.[1]	high-tension[3]	st. feed pump splash	Kingston	thermo-syphon	throttling[2]	G	0.735	17,680	50	6½	7	500
F	hor., opposed, 2-cyl.[1]	dual	mech. st. feed oiler	Rayfield	thermo-syphon	throttling[2]	G	0.730	20,600	40	8	9	350
G	vert., L-head, 4-cyl.[1]	high-tension[3]	pump splash	Bennett	pump	throttling[2]	G	0.737	20,000	35	5	7	700
H	hor., L-head, 4-cyl.[1]	high-tension[3]	mech. st. feed oiler	....	pump	throttling[2]	K	0.789	19,900	25	5¼	8	575
J	hor., opposed, 2-cyl.[1]	high-tension[3]	pump splash	Kingston	thermo-syphon	throttling[2]	G	0.747	19,550	25	6½	7	570
K	vert., L-head, 4-cyl.[1]	high-tension[3]	pump splash	Bennett	pump	throttling[2]	G	0.737	20,000	20	4¼	5¾	800
L	hor., single-cyl.[1, 5]	low-tension[6]	sight-feed oiler	....	hopper	throttling[2]	K	0.805	19,280	16	8	12	400
M	hor., L-hd., 2-cyl., opp[1]	Kingston dual h.-t.	mech. st. feed oiler	Kingston	pump	throttling[2]	G	0.738	20,290	20	5¼	7	650 / 720

[1] With mechanically operated inlet and exhaust valves.
[2] High-speed throttling type of governor that regulates the quantity of mixture.
[3] With K-W impulse starter magneto.
[4] Diaphragm type, using pressure of circulating water to control the speed.
[5] Valve in the head.
[6] Make-and-break system using an Accurate oscillating magneto.

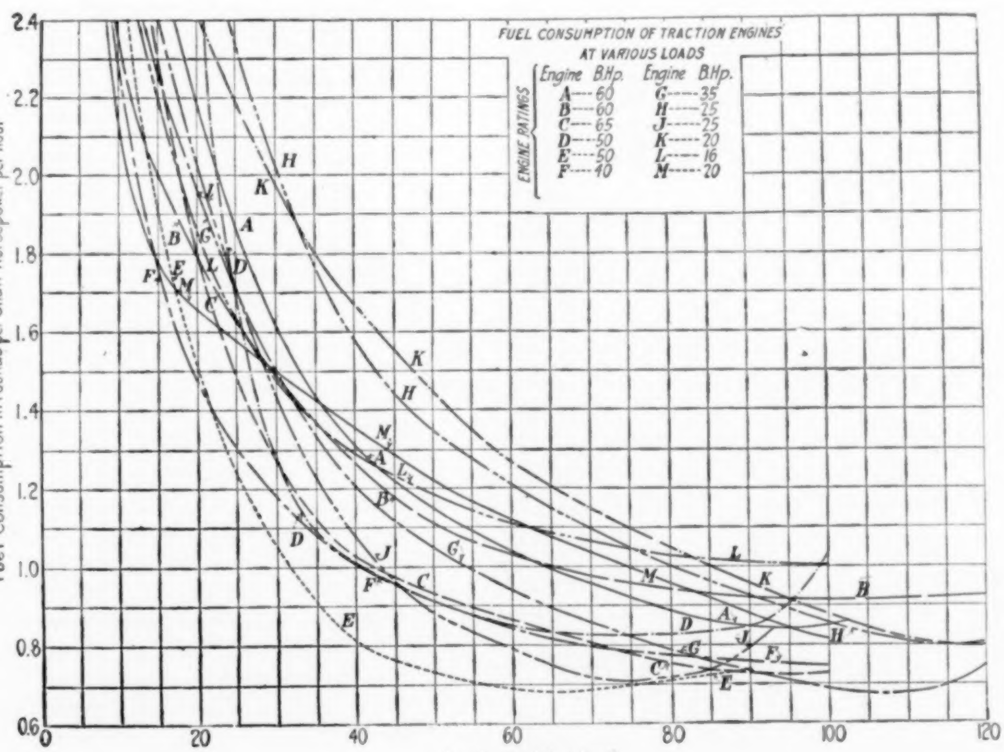

FIG. 1 CURVES OF FUEL CONSUMPTION OF TRACTION ENGINES AT VARIOUS LOADS

combustion space and is to be preferred to the T-head or L-head types.

g The combination of the forced feed and splash oiling system gives good results.

h The jump-spark system, on account of its mechanical simper hour is very nearly the same for both gasoline and kerosene.

j The thermal efficiencies at full load vary from 14.88 to 19.41 per cent for gasoline fuel, and from 13.7 to 15.97 per cent for kerosene.

RESULTS OF TESTS

The paper includes a table giving results of the tests relating to fuel consumption and thermal efficiency at various loads, and from the former the curves of Fig. 1 have been plotted.

TABLE 2 COST OF TRACTION-ENGINE POWER WITH GASOLINE AND KEROSENE AS MOTOR FUELS

Per Cent Load	Cost per Horsepower-Hour in Cents with								
	60° Baumé Gasoline at Prices per Gallons (in Cents) of					45° Baumé Kerosene at Prices per Gallon (in Cents) of			
	9	12	15	18	21	5	7	9	11
Group I[1]									
25	2.72	3.62	4.53	5.43	6.34	1.49	2.10	2.70	3.30
50	1.68	2.24	2.80	3.36	3.93	0.95	1.33	1.71	2.09
75	1.38	1.83	2.30	2.75	3.22	0.78	1.10	1.41	1.71
100	1.25	1.67	2.09	2.51	2.93	0.70	0.98	1.26	1.54
Group III[2]									
25	2.16	2.88	3.59	4.31	5.03	1.37	1.92	2.47	3.02
50	1.37	1.82	2.27	2.78	3.18	0.89	1.25	1.61	1.97
75	1.14	1.53	1.90	2.29	2.67	0.76	1.06	1.37	1.67
100	1.07	1.43	1.78	2.14	2.50	0.73	1.03	1.32	1.61

[1]Motors developing 15 to 26 b.h.p. on full load.
[2]Motors developing over 51 b.h.p. on full load.

TABLE 3 VALVE TIMING FOR MOTORS OF TRACTION ENGINES

Speed of Motor, r.p.m.	Exhaust Valve		Inlet Valve	
	Opens before outer center	Closes after inner center	Opens after inner center	Closes after outer center
200	20° to 25°	0° to 3°	0° to 3°	15° to 20°
300	22° to 27°	0° to 5°	2° to 5°	15° to 20°
400	27° to 32°	2° to 5°	2° to 7°	15° to 20°
500	30° to 35°	4° to 8°	5° to 10°	18° to 23°
600	35° to 40°	4° to 8°	8° to 12°	18° to 23°
700	40° to 45°	6° to 10°	10° to 12°	20° to 25°
800	45° to 50°	6° to 10°	10° to 12°	20° to 25°

CONCLUSIONS FROM TESTS

The lower fuel economy shown for engine A as compared with engine B (the same engine) was due to the greater spark advance used in operating engine A, when more cooling water had to be injected into the cylinder with the fuel to prevent pre-ignition. Water injection had to be used also during the tests of engines D, E and F with gasoline fuel.

In the case of several engines the valve setting had to be changed before satisfactory operating conditions could be secured. In one case the preliminary tests indicated that the carburetor was too small for the engine. Some companies in such cases remove several balls from the auxiliary air valve, a practice which is followed by poor fuel economy of the engine. These experiences indicate the poor inspection and testing facilities prevalent with some manufacturers of traction engines.

In order to facilitate comparison of various types, the motors tested were divided into the following groups, according to power developed at full load: I, 15 to 26 b.h.p. (motors H, J, K. L and M); II, 26 to 51 b.h.p. (D, E. F and G); III, over 51 b.h.p. (A, B and C). The average fuel consumption at different loads was then determined for groups I and III, and Table 2 computed. Group II is not considered in this table, as the engines it comprises were not operated on kerosene.

Table 2 shows the advantages of the kerosene-burning engine. Considering Group I, with kerosene at 10 cents per gal. and gasoline at 20 cents, the cost with gasoline fuel will be 1.99 times that with kerosene fuel for the same power developed. For Group III, the ratio will be 1.62 to 1 with prices of fuel the same. The advantages of the kerosene engine are offset to a greater or less degree, depending upon the operator, by the added trouble in handling. The life of the motor will also be somewhat shortened when using kerosene fuel. To this should be added the lower reliability with the heavier fuel. In some work done by traction engines reliability is the main factor.

Due to the high price of gasoline new carburetors are being placed on the market which handle kerosene very satisfactorily, and eventually it will be used more as a fuel for traction engines than will gasoline.

A study of the valve timing of the different motors in these tests shows no uniformity, except that the majority of the motors are so timed that the inlet valve does not open until after the exhaust valve is closed. The timing given in Table 3 is offered as a result of the authors' study and experience with traction engines.

From Fig. 1 it is evident that several of the motors are not rated at the capacity for best efficiency. The motors represented by tests G, H, K and M are underrated, E and J are overrated, while A, B, C and F are properly rated.

THE RATIO OF THE SPECIFIC HEATS AND THE COEFFICIENT OF VISCOSITY OF NATURAL GAS FROM TYPICAL FIELDS

BY ROBERT F. EARHART,[1] COLUMBUS, OHIO

Non-Member

THE present paper may be considered an extension of a previous paper on the physical properties of natural gas.[2] The object of the study with which it deals was to secure measurements on the ratio of the specific heats and the coefficient of viscosity of products similar to those previously studied in the Boyle's Law tests.

A knowledge of the ratio of the specific heats is necessary in computations involving adiabatic changes represented analytically by the well-known formula $PV^n =$ constant, where $n =$ ratio of the specific heats. Physical tables give value of this constant for all of the common gases. The following values, taken from the tables prepared by the French Academy of Sciences in 1913, are for gases frequently found in our natural-gas products. The results apply to pure gases in a dry condition.

Air	1.405	Methane	1,318
Nitrogen	1.410	Carbon Dioxide	1.300
Carbon Monoxide	1.400	Ethane	1.182
Oxygen	1.398		

The composition of natural gas, while fairly constant for any field, varies greatly for different regions. The value for

[1] Professor of Physics, Ohio State University.

[2] Deviation of Natural Gas from Boyle's Law, by R. F. Earhart and S. S. Wyer, read at Spring Meeting (April, 1916), Am.Soc.M.E.

For presentation at the Annual Meeting of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, New York, December 5 to 8, 1916. The paper is here printed in abstract form, and advance copies of the complete paper may be obtained gratis upon application. All papers are subject to revision.

n used by engineers is usually derived from the data supplied by indicator cards of gas compressors. Various assumptions in securing these values are made, and experience shows that different compressors operating on the same gas give different values.

The methods employed in the present study involve no new principles nor is originality of method claimed. Methods commonly used on pure gases have been merely adapted and utilized for securing appropriate and, it is hoped, accurate data on several of these complex natural products. Gas from ten localities has been secured. Three samples are from Pennsylvania, three from Ohio, two from West Virginia and two from Texas. In each case there was made (*a*) a chemical analysis, (*b*) a density determination by direct weighing, (*c*) a determination of n, and (*d*) a determination of the coefficient of viscosity.

DETERMINATION OF THE RATIO OF SPECIFIC HEATS

The classical method of Clement and Desormes for determining n, while exceedingly simple in theory and giving absolute values, does not afford satisfactory results for the reason that the adiabatic expansion assumed is not easily realized. This is the fundamental objection to the indicator-card method to which reference was made in an earlier paragraph. The most complete approach to adiabatic changes in gases is found in the transmission of sound waves.

The velocity of transmission of a compression wave through an elastic medium is given by the relation $V = \sqrt{(E/d)}$, where V = velocity of propagation, E = elasticity of the medium, and d = density of the medium. When the medium through which the disturbance passes is a gas, there are two cases: (1) An isothermal compression in which the previous relation becomes $V = \sqrt{(P/d)}$, where P and d are respectively the pressure and density of the gas; (2) an adiabatic compression. In the latter case the relation becomes $V = \sqrt{(nP/d)}$, where n = ratio of the specific heats, the other symbols as before. In the transmission of sound waves through a gas the velocity of the waves is so great and the character of the medium such that adiabatic conditions are almost perfectly realized.

In order to compare the value of n for a gas with the value of n for air, we have to compare the velocity of sound in the two media under the same pressure conditions and to know the relative density of the gas to air.

Letting $N(n)$ = ratio of the specific heats for air (gas)
$D(d)$ = density of air (gas)
P = pressure
$V(v)$ = velocity of sound in air (gas)
we have the following ratio:

$$\frac{V^2}{v^2} = \frac{(NP/D)}{(np/d)}$$

If the velocity be determined in the two media at the same pressure, then $n = N\,\frac{v^2}{V^2}\,\frac{d}{D}$, or $n = N\,\frac{v^2}{V^2}\int d$ (where the density of the air equals unity).

The experimental work resolves itself into comparing the density of gas with air at the same pressure and temperature and in comparing the velocity of sound in gas with that of air for this pressure. The latter comparisons were made by the usual method employed in laboratory investigations—that of Kundt, in which air or gas is set into longitudinal vibration inside a closed glass tube, and the nodal points of the resulting stationary waves are indicated by the disposition of lycopodium powder previously introduced. The distance between nodes equals a half wave length. In a 5-ft. tube 10 or 12 nodes may be distinctly observed, and these may be measured to within an accuracy of 1 mm. The relation between velocity V, frequency m, and wave length l is $V = lm$. Also, provided m is not altered by temperature or by displacements of apparatus, $V/l_{air} = m = v/l_{gas}$ which, substituted in the final equation of the preceding parapraph, gives

$$n = \frac{N(l_{gas})^2}{(l_{air})^2}\,d$$

The following data from the record illustrate the application and indicate the magnitude of the quantities involved. The value of N for air is taken as 1.405. The results here computed appear again in Table 1.

May 4, 1911.
Gas from the Geo. Secest farm, Vinton County, Ohio.
Tank filled at 200 lb. gage pressure.
Temperature, 20 deg. cent. Barometric pressure, 29.25 in.
To determine density,

Weight of glass bulb exhausted	= 146.370 grams
Weight of glass bulb filled with gas	= 146.750 grams
Weight of glass bulb filled with air	= 146.946 grams
Weight of gas = 146.750 − 146.370	= 0.380 gram
Weight of air = 146.946 − 146.370	= 0.576 gram
Relative density = 0.380/0.576	= 0.666

TABLE 1 DATA ON NATURAL GAS FROM TEN U. S. FIELDS

Sample	Chemical Analysis					B.T.U. per Cu. Ft.[1] (at 32 deg. fahr. and 76 cm.)	Density (Air = 1.0)	Ratio of Specific Heats, n.	Relative Coefficient of Viscosity	Coefficient of Viscosity in C.G.S. Units
	CO_2	O_2	CH_4	C_2H_6	N_2					
Air	....	...	...	...	...	....	1.000	1.405	1.000	178×10^{-6}
West Virginia, Ravenswood	0.0	0.0	82.0	17.5	0.5	1200	0.682	1.238	0.770	137×10^{-6}
West Virginia Connecting Gas Co.	0.0	0.0	86.1	12.1	1.8	1143	0.660	1.214	0.730	130×10^{-6}
Ohio, Sugar Grove Field	0.0	0.0	82.4	6.2	11.4	992	0.660	1.209	0.750	133×10^{-6}
Ohio, Homer Field, Licking County	0.0	0.0	78.8	14.2	7.2	1099	0.690	1.210	0.735	131×10^{-6}
Ohio, Vinton County Field	0.1	0.8	73.0	5.8	20.3	885	0.666	1.259	0.750	133×10^{-6}
Penna., Trafford City	0.2	0.0	95.0	0.0	4.9	1012	0.585	1.285	0.710	126×10^{-7}
Penna. Wet Gas, Ludlow East Branch Intake	0.0	0.0	66.4	34.6	0.0	1351	0.755	1.293	0.760	135×10^{-6}
Penna. Dry Gas, Royston, Penna	0.1	0.0	74.4	21.8	3.7	1198	0.678	1.220	0.750	133×10^{-6}
Texas, Beatty County	0.2	0.0	55.4	8.0	36.4	739	0.755	1.290	0.820	146×10^{-6}
Texas, Lone Star	0.1	0.0	50.0	10.0	39.9	718	0.770	1.224	0.830	147×10^{-6}

[1] B.T.U. calculated on Bureau of Mines values for CH_4 (= 1065) and C_2H_6 (= 1861).

DETERMINATION OF WAVE LENGTHS

Tube Contains Gas		Tube Contains Air		Tube Contains Gas	
Nodal points on meter stick	Half wave length	Nodal points on meter stick	Half wave length	Nodal points on meter stick	Half wave length
77.4 cm.	8.5 cm.	85.6 cm.	7.3 cm.	84.6 cm.	8.6 cm.
68.9	8.6	77.7	7.3	76.0	8.5
60.3	8.6	70.4	7.4	67.5	8.5
51.7	8.2	63.0	7.4	59.0	8.5
42.5	8.5	55.6	7.4	50.5	8.6
34.0	8.6	48.2	7.3	41.9	8.5
25.4	8.5	40.9	7.2	33.4	8.6
16.9	8.5	35.6	7.3	24.8	8.5
8.4	8.4	26.2	7.5	16.3	8.5
0.0	——	18.7	7.3	7.8	——
	Av. 8.49	11.4	7.2		Av. 8.53
		4.2	——		
			Av. 7.34		

Half wave length in gas = (8.49 + 8.53)/2 = 8.51 cm.

$$n = 1.405 \times \left(\frac{(17.02)^2}{(14.68)^2}\right) \times 0.666 = 1.259$$

In obtaining the data just given, gas was taken directly from the sampling tank without drying or processing of any kind. An experiment was made upon one sample both in the raw state and after passing through a calcium-chloride tube to remove water vapor. The density and wave-length measurements were modified by this, but when combined in the formula for determining n the result was changed by less than one-half of one per cent, which is about the limit of accuracy of the experiment. The value of n found for the raw gas was 1.259; for the dried gas it was 1.257.

DETERMINATION OF THE COEFFICIENT OF VISCOSITY

The coefficient of viscosity is used in computations involving the flow of gas through pipes of considerable length. Two methods are commonly employed for determining this constant. In the method used in this investigation gas is slowly forced through a long capillary tube. The rate of flow is a function of the coefficient of viscosity and is determined by means of the formula[1]

$$V_a = \frac{(p_a^2 - p_e^2)\,R^4}{16\,CLp_e}$$

V_a = volume of gas passing through the capillary per unit time
p_a and p_e = pressure of gas before and after escape
R = radius of capillary
C = coefficient of viscosity
L = length of tube.

A consideration of this formula shows that if equal volumes of two gases under similar pressure and temperature conditions are passed through a long capillary tube, the coefficients of viscosity are in the ratio of the times of efflux. The value of the coefficient of air has been carefully studied during the past ten years on account of its importance in certain electrical measurements. Calling C_g (C_a) the coefficient of viscosity of the gas (air) and t_g (t_a) the time of transportation for the gas (air),

$$C_g = C_a \frac{t_g}{t_a}$$

It was customary to make three measurements with dry air, then a series of three measurements on the gas, to be followed by one or two additional measurements on air.

The chemical analyses were made in the Mines Laboratory of the Ohio State University by Mr. E. C. Smith.

SUMMARY

To summarize,

a Determinations of the exponent n in the expression for adiabatic change PV^n = constant have been made on ten samples of natural gas. The lowest value obtained was 1.209, the highest 1.293. The maximum variation from the mean value (1.243) is 4 per cent.

b Determinations of the coefficient of viscosity give values ranging from 126×10^{-6} to 147×10^{-6} C.G.S. units.

[1] For derivation, see Wüllner, Lehrbuch der Physik, vol. 1, p. 629.

TEXTILE PAPERS

THE work of the Sub-Committee on Textiles is devoted to securing papers upon the mechanical engineering and allied features of the textile industry. The Sub-Committee contributes three important papers to the Annual Meeting this year, one of which, bearing upon the heating of mill buildings, is published below.

HEAT TRANSMISSION THROUGH VARIOUS TYPES OF SASH AND THE CAUSES AND PREVENTION OF INTERNAL CONDENSATION IN DOUBLE-GLAZED SASH

By ARTHUR N. SHELDON, PROVIDENCE, R. I.

Member of the Society

IN the industrial plant of today, where there is so much emphasis placed upon maximum daylight, exterior wall surfaces consist principally of windows, and the heat loss through them is a very important matter. Indeed there may be a question in certain plants whether the window area is not carried to excess—that is beyond a point where increased daylight warrants the increased heat loss. In the absence of authentic data on the relative heat loss through various types of sash, these experiments were conducted by Mr. W. S. Brown, under the writer's direction, to enable us to logically design and proportion the fenestration of industrial buildings.

For presentation at the Annual Meeting of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, New York, December 5 to 8, 1916. The paper is here printed in abstract form and advance copies of the complete paper may be obtained gratis upon application. All papers are subject to revision.

DESCRIPTION OF APPARATUS

The sash tested were of such a size as completely to fill an opening on the face of a test box 4 ft. 2¾ in. wide by 7 ft. 9½ in. high, the test box being 1 ft. 2 in. deep. The box was constructed of 2-in. tongued and grooved white pine, covered

with 2-in. cork boards and made airtight. Wool felt 1 in. thick was placed between the edge of the test box and the sash to reduce air leakage to a minimum. The box rested on two gypsum blocks as shown in Fig. 1.

The test box being set up on end, an electric heater was placed in the bottom. The heater consisted of six sets of resistance wire strung horizontally, and arranged so that, beginning at the bottom, the first two coils might dissipate approximately 0.25 kw. each of electrical energy, the next two 0.50 kw. each, and the uppermost two 0.75 kw. each. The switching arrangement was designed to give a total capacity of 3 kw., obtainable in successive stages of 1/8 kw. each. Fig. 2 shows the arrangement of the heater and the 1/4-in. asbestos board plates, 15 in. high, which were fastened against the lower frame of the heater to prevent direct radiation of heat to the lower panes of glass.

Air temperatures within the box were recorded by twelve thermometers, arranged opposite the various panes of glass, and giving a fair average of the internal temperatures. The total average temperature was obtained by averaging the individual temperatures behind each horizontal row of panes. The Fahrenheit long-scale chemical thermometers used protruded about 7 in. through the back of the box and its covering, and were tested for accuracy before and after the experiments.

Air temperatures outside the box were observed by means of an accurate wall thermometer, registering maximum and minimum temperatures. A thermostatically controlled steam radiator maintained a constant temperature outside. Two electric fans directed currents of air against the test box at an angle of 30 deg., and provided a positive and constant circulation over it. While it was not possible or necessary to reproduce actual wind conditions, 11½ mi. per hr. for New England during the heating season, anemometer readings during the tests showed that the conditions obtained were not far from the average to be expected. Vertical baffles protected the back and sides of the box from the air currents.

Measurements of electrical energy converted into heat were obtained simultaneously by means of two meters, the first a standard indicating wattmeter, accurate within 1/4 of one per cent, and compensated for temperature changes, and the other a standard service watt-hour meter, installed and adjusted by the service company furnishing the power.

The humidity of the air was kept as constant as possible throughout the series of tests by means of water-saturated felt, and was measured by a wet- and dry-bulb hygrometer. The humidity remained constant during the period of each individual test.

METHOD OF CONDUCTING TESTS

The average temperature of New England during the heating season being 36 deg. fahr., it was decided to make tests at a room temperature corresponding to 76 deg., or a temperature difference of 40 degrees. For greater accuracy, and to obtain the transmission rate in colder weather, there were tests made at 70 deg. temperature difference as well.

To determine what amount of heat was transmitted through the sides and back of the test box, blank runs were made in which the opening in the face of the box was closed by materials of which the box itself was made. These tests were run very carefully over an extended period of time (at least 18 hr.) to make sure that all conditions had become constant, after which hourly readings were taken for eight hours. The temperature difference during the run did not vary more than 1 deg. fahr. The fans were not in operation during the blank-run tests, as the object was to determine the rate of transmission through the box and covering under the conditions of the test; still air on top, sides, back and bottom. In order to reduce any slight error due to a possible change in conductivity of the box itself during the experiments, tests were run to obtain these constants at 40 deg. to 70 deg. heat head both before and after the series of sash tests. It was found that a slight increase occurred due evidently to shrinkage and warping of the boards.

Sash tests were conducted in the same manner, except that the fans were put in operation. In each separate test, the watt-hour meter was calibrated for the load by timing it for ten minutes with the instantaneous meter and counting the revolutions of the disk. During all tests, a careful record was kept of the panes of glass on which condensation occurred.

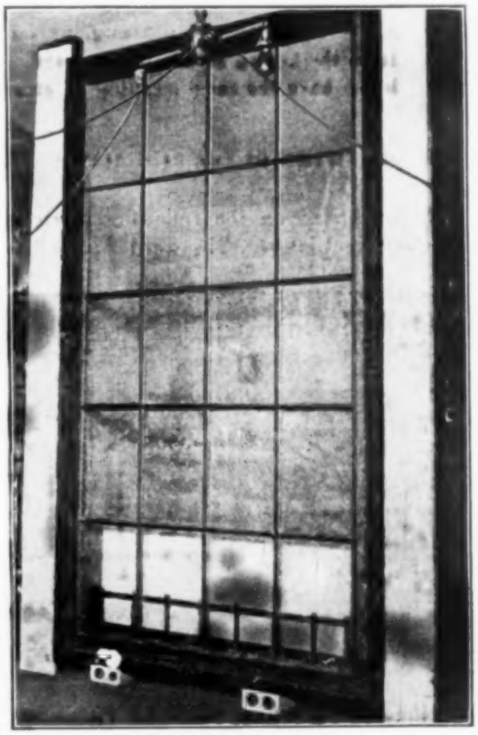

FIG. 1 SASH IN FRONT OF TEST BOX

COMPUTATIONS OF TESTS ON HEAT TRANSMISSION

The heat transmission through the sash has been worked out and expressed on the basis of B.t.u. transmitted per 24 hr. per deg. fahr. per sq. ft. of opening, and is designated in the formula following as H, whence

$$H = (L - l)/ad \qquad [1]$$

where

L = total heat loss through test box and sash in B.t.u. per 24 hr. as computed from wattmeter measurements

l = heat loss in B.t.u. per 24 hr. through top, bottom, back and sides of test box, as determined from blank run and corrected for actual temperature difference during test

a = area of opening filled by sash = 33 sq. ft.

d = temperature difference throughout test

L is found from the formula

$$L = (w \times 3412 \times 24)/t \qquad [2]$$

where

w = electrical energy dissipated in heater as measured in kilowatts at average temperature d

t = duration of test, hours

3412 = the equivalent of 1 kw. in B.t.u.

In the same manner l is found from the blank-run tests by the formula

$$l = R(w \times 3412 \times 24)/t \qquad [3]$$

where

R = the ratio of the top, bottom, sides and back of the box exposed during the sash tests, to the total area of the box, or that exposed during the blank run. As noted above, l should be taken at the same temperature as L by interpolation from the known results if necessary. The other terms have the same meaning as above.

DESCRIPTION OF THE SASH TESTED

Tests were conducted on the following seven samples of sash, all without ventilators. The word "pane" refers to a single sheet of glass, whereas "light" refers to a section of sash, or, in the case of double-glazed sash, two panes and the air space.

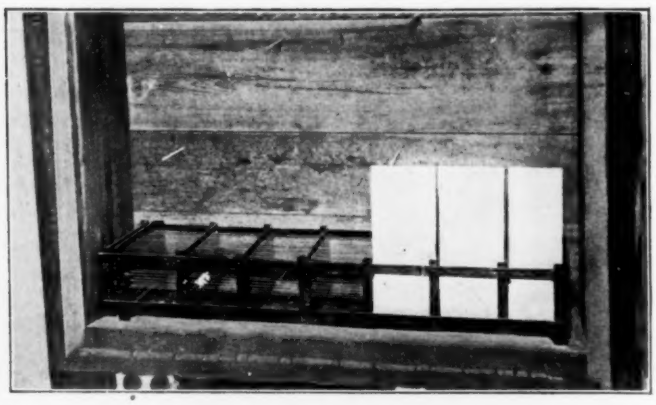

FIG. 2 INTERIOR OF TEST BOX, SHOWING THERMOMETERS AND THREE ASBESTOS PLATES

Sample No. 1 was standard single-glazed, solid, rolled-steel sash of 20 panes, each approximately 12 by 18 in., arranged 4 wide by 5 high. The panes were ¼-in. rough wire glass. The sash bar section was 1⅜ in. deep, the glass being bedded on the front side and puttied from the inside, the putty having a good half-inch body. The exposed glass area was 28 sq. ft., or 85 per cent of the total.

Sample No. 2 was a double-glazed, solid, rolled-steel sash of same size and arrangement of lights as Sample No. 1. The outside panes were ⅛-in. factory ribbed glass (ribs inside) and the inside panes were single-thick plain glass separated from the former by a galvanized-iron channel separator, making a 3/16-in. air space. The sash bar was 1⅜ in. deep, the outer pane being bedded on the outside and the inner pane put on with a good ½-in. body of putty. The glazing was done from the inside.

Sample No. 3 was a double-glazed, solid, rolled-steel sash of the same make, size and arrangement of lights as Sample No. 1. The outside panes were ¼-in. rough wire glass, the inside panes being single-thick plain glass, separated from the former by a galvanized iron channel separator, making a ¾-in. air space. The sash bar was 2⅜ in. deep, the outer pane being well bedded on the outside with a 11/16-in. body of putty. The glazing was done from the inside.

Sample No. 4 was an ordinary double-glazed wood sash, of same size and arrangement of lights as Sample No. 1. The outside panes were ¼-in. rough wire glass, the inside being double-thick plain glass separated from the former by a ⅝-in. air space. The sash was made of 1¾-in. stock, muntin bars being 5/16 in. The outer panes had a 5/16-in. body of putty and the inner panes ½-in. body, bedded. Glazing was done from both sides.

Sample No. 5 was a single-glazed wood sash of the same size and arrangement of lights as Sample No. 1, and was obtained from No. 4 by taking out the inside panes of plain glass.

Sample No. 6 was a double-glazed, hollow metal sash. The lights were made larger than those of Sample No. 1, being 14½ in. by 21 in. and arranged three wide and four high. The outside panes were ¼-in. rough wire glass, the inside being single thick, plain glass, separated from the former by a ¾-in. air space. The exposed glass area was 23.5 sq. ft., or 71.5 per cent of the total. The sash bar was 2⅛ in. deep. Muntin bars were 1¾ in. in external width. The outer panes were bedded to the outside and the inner panes were bedded to both sides.

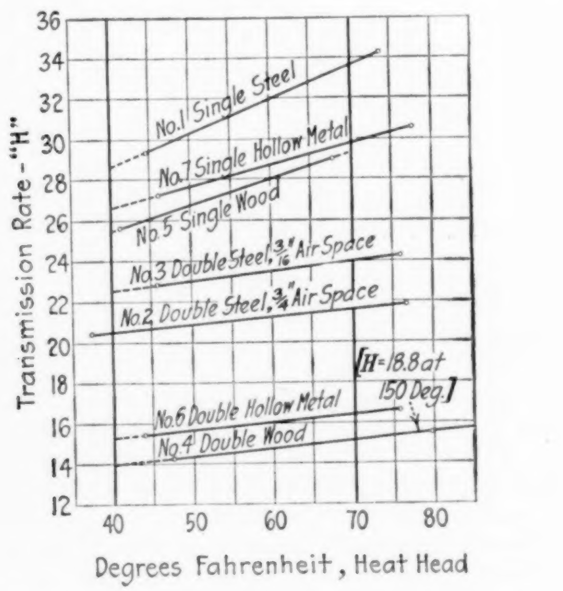

FIG. 3 VARIOUS TRANSMISSION RATES, H, FROM TESTS

Sample No. 7 was a single-glazed, hollow metal sash, of the same arrangement of lights as Sample No. 6, being obtained from it by removing the inside panes of plain glass, together with the galvanized-iron-formed sections which held them in place. This left the muntin bars 1½ in. deep.

RESULTS OF TESTS

A résumé of the comparative heat-transmission rates, H, of formula 1, as deduced from the tests, is given in Tables 1 and 2.

The results of the tests have been plotted in the form of

curves (Fig. 3). It will be noted that the rate of transmission increases with the temperature difference, and that there is a greater increase for the single- than for the double-glazed sash.

To ascertain the cause of the much greater heat-transmission rate through solid steel compared with wood and hollow metal sash, a thermometer was inserted in a chamber in a 2-in. cork board, which, in turn, was placed against the bars of the sash. These tests showed that for a given temperature difference the steel bars were hotter than the wooden, and by their greater conductivity constituted a direct path for the transmission of heat to the outside. The hollow steel sash bars were warmer than the wood, but cooler than the solid steel. The steel bars also serve to increase the temperature of the air in the same space between panes in the double-glazed sash, and hence increase the transmission rate through the panes.

TYPICAL PROBLEM IN RELATIVE COSTS

In order to emphasize the practical application of these experiments, a typical problem is given. In the design of reinforced-concrete buildings there arose the question whether to use single- or double-glazed steel sash. The following data apply to the problem:

Wall openings to be glazed	37,800 sq. ft.
Average inside temperature, heating season	70 deg. fahr.
Average outside temperature, heating season	35 deg. fahr.
Average temperature difference, 70 — 35 deg. fahr.	35 deg. fahr.
Heat delivered from steam plant per pound of coal	8500 B.t.u.
Length of heating season	4850 hours
Cost of coal per 2000 lb.	$4.00
Assumed cost of hot-water heating plant per square foot of heating surface, including heater, based on — 10 deg. fahr. outside temperature	$0.60

Proposition A, single-glazed steel sash. From the tests, H at 35 deg. fahr. = 27.7 B.t.u. per degree difference in temerature per square foot per 24 hours.

Comparative yearly coal bill[1]	$1,750.00
Comparative initial investment cost of sash erected.	15,600.00
Cost of heating system to supply heating loss only, based on 18,400 sq. ft. at $0.60	11,040.00
Total investment	$26,640.00

Proposition B, double-glazed steel sash, 3/16-in. air space. From the tests, H at 35 deg. fahr. = 22.3 B.t.u. per degree difference in temperature per square foot per 24 hours.

Comparative yearly coal bill	$1,410.00
Comparative initial investment cost of sash erected.	21,000.00
Cost of heating system to supply window loss only, based on 12,800 sq. ft. at $0.60	7,680.00
Total investment	$28,680.00

Proposition C, double-glazed steel sash, 3/4-in. air space. From the tests, H at 35 deg. fahr. = 20 B.t.u. per degree difference in temperature per square foot per 24 hours.

[1] $\dfrac{\$4.00 \times 37{,}800 \text{ sq. ft.} \times 27.7 \text{ B.t.u.} \times 4850 \text{ hr.} \times 35°\text{F.}}{2000 \text{lb.} \times 24 \text{ hr.} \times 8500 \text{ B.t.u.}} = \$1750.00$

TABLE 1 HEAT-TRANSMISSION RATES AT APPROXIMATELY 40 DEG. FAHR. TEMPERATURE DIFFERENCE

Sample	Actual Heat Head, Deg. Fahr.	H Computed at Actual Heat Head	H Corrected to 40 Deg. Fahr. Heat Head	Relative Humidity	Condensation
No. 1 Single-glazed solid steel	44.5	29.3	28.5	36	None
No. 2 Double-glazed solid steel, ¾-in. air space	37.4	20.4	20.5	34	None
No. 3 Double-glazed solid steel, ⅝-in. air space	45.7	22.8	22.5	43	Very slight on air-space side of one outside pane and box side of one inside pane
No. 4 Double-glazed wood, ⅝-in. air space	47.3	14.2	13.9	49	None
No. 5 Single-glazed wood	41.2	25.6	25.5	44	Hardly noticeable
No. 6 Double-glazed hollow metal, ¾-in. air space	43.9	15.4	15.2	54	On air-space. side of one of outside pane
No. 7 Single-glazed hollow metal	46.0	27.1	26.4	43	All

TABLE 2 HEAT-TRANSMISSION RATES AT APPROXIMATELY 70 DEG. FAHR. TEMPERATURE DIFFERENCE

Sample	Actual Heat Head, Deg. Fahr.	H Computed at Actual Heat Head	H Corrected to 70 Deg. Fahr. Heat Head	Relative Humidity	Condensation
No. 1. Single-glazed solid steel	73.9	34.2	33.6	28	All
No. 2 Double-glazed solid steel, ¾-in. air space	76.8	21.8	21.6	29	15 outer panes out of 20 showed moisture on air-space side
No. 3 Double-glazed solid steel, ⅝-in. air space	76.0	24.2	24.0	30	One outer pane showed moisture on air-space side; one inner pane showed moisture on box side. Three lights showed both above
No. 4[1] Double-glazed wood, ⅝-in. air space	79.8	15.5	15.1	31	None
No. 5 Single-glazed wood	67.6	28.9	29.3	29	12 lights
No. 6 Double-glazed hollow metal, ¾-in. air space	75.6	16.6	16.4	36	On air-space side of one outside pane
No. 7 Single-glazed hollow metal	77.7	30.5	29.7	25	All

[1] A test upon this same wood sash with the inside single-thick plain glass substituted for the double-thick showed an increase in H of 3 per cent at 70 deg. fahr. temperature difference.

Comparative yearly coal bill..................... $1,260.00
Comparative initial investment of sash erected..... 25,750.00
Cost of heating system to supply window loss only, based on 11,500 sq. ft. at $0.60............... 6,900.00

Total investment.........................$32,650.00

From Table 3 it is evident that an investment of $2040.00 for *B* over that for *A* would result in an annual saving of $340.00 worth of coal, or 17 per cent gross on the additional investment. Also, an additional investment of $6010.00 for *C* over that of *A* would result in an annual saving of $490.00 worth of coal, or only 8 per cent gross on the additional investment. The choice, therefore, lies between A and B; and whether or not *B* should be preferred will depend largely upon what earning the owners expect to make upon their other investments. It should be emphasized here that with a different unit cost of coal, a warmer or a cooler climate, or a different heating system, the conclusion might be changed entirely.

TABLE 3 SUMMARY OF RESULTS

	Yearly Coal Bill	Initial Expenditures		
		Sash	Heating System	Total
Proposition *A*..........	$1,750.00	$15,600.00	$11,040.00	$26,640.00
Proposition *B*..........	1,410.00	21,000.00	7,680.00	28,680.00
Proposition *C*..........	1,260.00	25,750.00	6,900.00	32,650.00

INTERNAL CONDENSATION IN DOUBLE-GLAZED SASH

Where condensation occurred in the air space, it was always on the outside pane of glass which of course was the cooler one. The wood sash showed none, but it was very marked in the solid steel, and not noticeable in the hollow metal sash. To determine, if possible, the cause for this condensation, holes were bored in some of the lights of the solid steel sash which had shown condensation, and in some which had not. Each light was then tested by blowing smoke into the hole, and some were found to leak considerably, some to adjacent spaces, others to front or back, and a few showed combinations of these conditions. It was observed that where condensation was evident, the greatest leakage was to the inside of the box, and that where there was no condensation, the greatest leakage was to the air outside the box.

Following this clue, the entire sash was reglazed, and holes bored in seven of the outer panes, and in five of the inner panes. Free communication was thus established either to the external cool air or to the warmer air inside the test box. Each pane of glass opposite those with holes was carefully bedded to confine and control the air leakage to the side having the hole. Smoke tests before and after each run showed that the desired object had been attained by this means. The remaining eight lights were made as air tight as possible on both sides by careful bedding and setting. The sash was then placed on the front of the box as in the previous tests, the temperature raised to about 70 deg. fahr. above that of the surrounding room, and records were kept as before of temperatures, relative humidity, and condensation, this being allowed to accumulate for a period of at least eighteen hours. The relative humidity in the test box was maintained at 40 per cent, and that of the air outside varied from 60 to 90 per cent, apparently having little effect upon the results.

A careful examination of the sash showed uniformly the following results:

a Lights in which the air space opened to the outside or *cooler* air only showed no condensation.

b Lights in which the air space opened to the *warm* air inside the box showed much condensation.

The sash was then reversed with its outer side toward the interior of the test box and, after a test of three days, examination showed that the air spaces in which there had been condensation during the previous test were now dry, while abundant condensation appeared in those which showed none in the first test. It was also discovered that by varying alternately the temperature in the test box, the processes of condensation and drying could be accelerated. The experiment on the reversed sash, therefore, confirmed conclusions *a* and *b* above.

The explanation is simple. Changes in temperature on either side of the sash cause corresponding, though less marked, changes in the temperature of the air space. The pressure of the confined air, therefore, becomes more or less than atmospheric and air is correspondingly either forced out or admitted through the drilled holes, and, if the temperature difference is alternately increased and decreased, a breathing action obtains in the air space. A similar action occurs through leaks in actual practice and is due to variations in temperature.

Air entering an opening of this kind *from the inside*, coming as it does from the warm interior of the test box or building, becomes chilled, condensation necessarily appearing if the cooling is carried below the dew point. Breathing, or a repetition of this process, necessarily results in a gradual accumulation of condensation.

Conversely, air entering an opening of this kind *from the outside* becomes heated and its relative humidity is correspondingly decreased, making impossible the precipitation of any moisture.

CONCLUSIONS

Condensation in the air space of double-glazed sash can be eliminated almost entirely by connecting the air space directly to the outside air, and at the same time effectively sealing it from the entrance of warm air within the building. In attempting the design of a double-glazed sash according to these principles, it is suggested that the following points be considered:

a The opening should be *very small*, say a 1/8-in. hole, to prevent a direct loss of heat by convection from the air space.

b The *location* of the breathing hole is immaterial, except that a consideration of heat economy makes the bottom preferable.

c The breathing hole should be protected from the weather and dirt.

d A high-grade, elastic putty should be used. On account of wind pressure, difference of expansion between steel and glass (about 65 per cent), careless setting, etc., absolute sealing of the inner panes probably will not be accomplished. However, these tests show that a sufficient degree of tightness can be obtained, and that the larger part of the breathing will occur through the opening made for this purpose.

e Leaks between air spaces should be eliminated.

INDUSTRIAL SAFETY PAPERS

THE Sub-Committee on Protection of Industrial Workers has this year received an important proposed code for safeguarding industrial risks which it will present for consideration and discussion at the Annual Meeting. The subject of this code is Safety Standards for the Operation of Cranes, and it has been prepared by committees of thirty-six representative gentlemen and companies.

PROPOSED CODE OF SAFETY STANDARDS FOR OPERATION OF CRANES

For the Consideration of the Sub-Committee on Protection of Industrial Workers of the American Society of Mechanical Engineers

Caution: Employees shall not remove or make ineffective any safeguards while same are in use, except for the purpose of making repairs, and such safeguards so removed shall be replaced.

THE following Standards apply to cranes which are regularly used in and form part of a permanent industrial plant. In addition to Electric Traveling Cranes, these regulations are to cover Jib Cranes, Monorail Cranes, Hand-Power Cranes, and other hoisting apparatus of a similar nature, in so far as the various sections apply.

The provisions of all Safety Standards issued by the Society shall[1] apply to all matters not specifically covered herein.

ELECTRIC TRAVELING CRANES

GENERAL CONSTRUCTION

1 Proper provisions for strength shall be made for all parts subject to impact and rough usage. Journals and shafts shall be of sufficient size to bring pressure within safe limits.

2 All apparatus shall hereafter be designed throughout with not less than the following factors of safety under static full rated load stresses, based on ultimate strength of material used:

a All gears, and complete hoisting mechanism, factor of not less than eight (8).

b All other parts, factor of not less than five (5).

3 Calculations for wind pressure on outside cranes shall be based on not less than thirty pounds per square foot of exposed surface.

4 Cranes should be of what is known as "All-Steel Construction;" no cast iron should be used except for such parts as drums, bearings, brackets, etc. No combustible material should be used.

5 All bolts should be of the through type, and be equipped with approved lock nuts or lock washers.

6 Where access to the crane is necessary, steps or stairs with hand rails should be used.

7 Platforms should be provided for changing and repairing truck wheels on end trucks and provided with stairways leading to them.

8 A platform or footwalk to give access to crane shall be provided accessible from one or more fixed ladders or stairways, and shall be not less than twenty (20) inches in width.

9 A footwalk shall be placed along the entire length of bridge on the motor side except when the construction of the crane prevents or when such platform would not ordinarily be used for the repair or maintenance of crane, and should be at least six feet six inches (6′ 6″) below the bottom of the overhead trusses.

10 Footwalks should be placed across the ends of the trolleys at right angles to the bridge walks and shall be not less than twelve (12) inches in width.

11 Footwalks shall be of substantial construction, rigidly braced.

12 On cranes hereafter erected no openings shall be permitted between bridge footwalks and crane girder. When wire mesh is used the mesh opening must not be greater than one-half (½) inch.

13 Each footwalk shall have a standard metal railing and toe guard at all exposed edges wherever practicable.

14 Not less than twelve (12) inches actual clearance should be allowed between highest point of crane and overhead trusses, and not less than two (2) inches between any part of crane and building, column, or other stationary structure. Where there are more than two crane runways in parallel there should be a clearance of not less than twenty-four (24) inches between the extremities of the cranes.

15 Means of escape shall be provided for operators of hot-metal cranes.

16 Operator's cage shall be located at a place from which signals can be clearly distinguished and be securely fastened in place and be well braced, to minimize vibration. It shall be large enough to allow ample room for the control equipment and the operator. The operator shall not be required to step over an open space of more than eighteen (18) inches when entering or leaving the crane.

A pail filled with sand or an approved fire extinguisher shall be carried in the crane cage for use in case of fire.

17 An approved foot- or hand-operated gong or other effective warning signal shall be placed in a location convenient to operator and be securely fastened.

18 Ladle and other cranes subjected to heat from below should have a steel-plate shield not less than one-eighth (⅛) inch thick and placed not less than six (6) inches below the bottom of floor of cage.

19 The cages of cranes hereafter erected shall be of fire-resisting construction.

20 All gears on cranes hereafter erected shall be provided with standard guards. This should apply to all existing cranes where practical.

21 No overhung gears shall be used unless provided with an effective means of keeping them in place, and keys shall be secured in an approved manner to prevent gears working loose.

22 Unprotected keys shall not be left projecting from ends of shafts.

23 The construction of the crane shall be such that all parts may be safely lubricated when the crane is not in operation.

24 The installation of switchboard, wiring and all electrical equipment must fully comply with the Industrial Board Standards.

25 There shall be a main-line switch or its equivalent so

[1] The word "SHALL" where used is to be understood as mandatory and "SHOULD" as advisory.

For presentation at the Annual Meeting of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, New York, December 5 to 8, 1916.

arranged as to cut off all power from crane, and so constructed that it may be locked in its open position.

26 Open-type controllers shall have asbestos-lined steel guards over the movable contact parts, both to protect operator's eyes and prevent articles falling on contact parts.

27 An approved hoist-limiting device, should be provided for each hoist.

28 Suitable brakes shall be provided for the hoist and bridge travel. Each hoist shall be equipped with effective brakes which shall be capable of sustaining at least one and one-half ($1\frac{1}{2}$) times the full rated load.

29 The drums on cranes hereafter erected shall have a flange at each end to prevent the ropes from getting off the drum, and be so designed that there will be not less than two full wraps of hoisting cable in the grooves when hook is at its lowest position.

30 Hook block shall be of a type so arranged that it will lift vertically without twisting.

31 Bottom sheaves shall be protected by close-fitting guards, to prevent rope from becoming misplaced.

32 Crane bumpers shall be provided and shall be at least one-half of the diameter of the truck wheel in height. Both truck wheel and trolley bumpers should be fastened to the girder and not to the rails. Bumpers shall be built up of plates and angles, or made of cast steel.

33 Truck fenders shall be installed which extend below top of rail and project in front of all bridge and trolley track wheels, and shall be attached to trolley or bridge and frame. They shall be of a shape and form that will tend to push and raise a man's hand, arm or leg off the rail and away from wheel.

34 Heavy safety lugs or brackets shall be placed on trolley frames and bridge end carriages, to limit drop to one inch or less if a wheel or axle should break.

35 A capacity plate showing the maximum capacity of each hoist in pounds shall be placed on each crane girder in such a manner as to be clearly legible from the floor.

36 A metal tool box or receptacle shall be permanently secured in the cage or on the runway for the storing of oil cans, tools, etc.

37 Trolley should be completely floored.

38 Cranes in outside service shall have the following additional provisions:

a Floors of footwalks to be so constructed as to provide proper drainage.

b Cage shall be enclosed and of fire-resisting construction; there shall be windows on three sides of cage; windows in front and side opposite door to be full width of cage.

c Floor of cage on outdoor cranes should be extended to an entrance landing which shall be equipped with handrail and toeguard of standard construction.

d Where there are no members over crane suitable for attaching blocks for repair work, a structural-steel outrigger should be arranged on the crane of sufficient strength to lift the heaviest part of the trolley.

39 All gantry cranes should be equipped with automatic warning signals.

40 The truck wheels of gantry cranes shall be provided with guards or fenders.

OPERATION OF CRANES

Rules for Operators

1 Cranes shall be operated only by regular crane operators, authorized substitutes, crane repairmen or inspectors; no one else should enter crane cage.

2 Hands shall be kept free when going up and down ladders. Articles which are too large to go into pockets or belts should be lifted to or lowered from crane by hand line (excepting where stairways are provided).

3 Cages shall be kept free of clothing and other personal belongings. Tools, extra fuses, oil cans, waste and other articles necessary in the crane cage shall be stored in a tool box, and not left loose on or about crane.

4 Operator shall familiarize himself fully with all crane rules and with the crane mechanism and its proper care. If adjustments or repairs are necessary, he shall report the same at once to the proper authority.

5 Operator should not eat, smoke or read while on duty nor operate crane when he is physically unfit.

6 Operator or some one specially designated shall properly lubricate all working parts of crane.

7 Cranes shall be examined daily for loose parts or defects.

8 Cranes shall be kept clean.

9 Operators shall avoid, as far as possible, carrying loads over workmen; it must be absolutely avoided when carrying molten metal or with magnet.

10 Whenever operator finds main or emergency switch open, he shall not close it, even when starting on regular duty, until he has made sure that no one is on or about the crane, and shall not oil or repair crane unless main switch is locked open.

11 Before closing main switch, operator shall make sure that all controllers are in "OFF" position.

12 If power goes off, operator shall immediately throw all controllers to "OFF" position until power is again available.

13 Operator should not reverse a motor until it has come to a full stop, except to avoid accidents.

14 Operator shall pay special attention to the block when long hitches are made, to avoid tripping limit switch or running block upon the drum.

15 Operator shall recognize signals only from the one man who is supervising the lift. Operating signals should follow an approved standard; they should be manual, never verbal. Whistle signals may be used where one crane only is in operation.

16 Before starting to hoist, operator shall place trolley directly over the load to avoid swinging it when being hoisted. This precaution is especially important when handling molten metal.

17 Operator shall not make side pulls with crane except when especially instructed by proper authority.

18 When handling maximum loads, particularly ladles of molten metal, operator shall test hoist brakes after load has been lifted a few inches; if brakes do not hold, load should be lowered at once and the brakes adjusted or repaired.

19 Bumping into runway stops or other cranes shall be avoided. When operator is ordered to engage with or push other cranes, he shall do so with special care for safety of persons and cranes.

20 When lowering a load, operator shall proceed carefully and make sure that he has the load under safe control.

21 When leaving cage, operator shall throw all controllers to "OFF" position and open main switch.

22 If crane is located outdoors, operator shall also lock crane in secure position to prevent it from being blown off or along the track by severe wind.

RULES FOR FLOORMEN

1 Floormen shall give all signals to the operator in accordance with approved standards, preferably manual.

2 Floormen shall be responsible for the condition and selection of all hoisting accessories and for all hitches.

3 Before operator moves crane upon which an empty chain sling is hanging, floorman should hook both ends of sling to block.

4 Floormen where necessary should walk ahead of moving load and warn people to keep clear of it. They shall see that load is carried high enough to clear all obstructions.

5 Floormen shall notify the foreman in advance when an extra heavy load is to be handled.

6 Floormen shall not ride or allow others to ride on hook or load.

RULES FOR REPAIRMEN

1 Repairmen should have crane that is to be repaired run to a location where the repair work will least interfere with other cranes and with operations on floor.

2 Before starting repairs, repairmen shall see that all controllers are thrown to "OFF" position; that main or emergency switches are opened, one of which shall be locked.

3 Repairmen shall immediately place warning signs or "OUT OF ORDER" signs on crane to be repaired and on floor beneath. If other cranes are operated on the same runway, he should also place rail stops at a safe distance or make other safe provision.

4 When repairing runways, repairmen shall place rail stops or warning signs or signals so as to protect both ends of section to be repaired.

5 Repairmen shall take care to prevent loose parts from falling or being thrown upon floor beneath.

6 Repairs shall not be considered complete until all guards and safety devices have been put in place and block and tackle and other loose material been removed.

CORRESPONDENCE

CONTRIBUTIONS to the Correspondence Departments of The Journal by members are solicited by the Publication Committee. Contributions particularly welcomed are suggestions on Society Affairs, discussions of papers published in The Journal or brief articles of current interest to the membership.

VERTICAL VS. HORIZONTAL OIL ENGINES

TO THE EDITOR:

The paper on heavy-oil engines by Mr. Daugherty in the October JOURNAL contains a discussion on the relative merits of horizontal and vertical engines, to the conclusions of which I cannot subscribe. As far as Mr. Daugherty's figures go, there is apparently nothing wrong, and his conclusions would be perfectly correct if we were interested only in the maximum side pressures that act upon the piston and cylinder. However, this is not a question of strength; we all know that no horizontal engine, any more than a vertical one, ever broke to pieces on account of the side pressures exerted upon the piston, or by the piston upon the cylinder. We do know, however, that under the same conditions the cylinders and pistons of horizontal engines wear out much more rapidly, and require more attention and cleaning, than those on vertical engines.

Wear is the result of friction load and rubbing speed which, applied to the case before us, necessitates an investigation into the piston speed and the pressures exerted upon piston and cylinder walls *during the whole cycle of operation.* The maximum side pressure, which occurs at one instant only during the four strokes of a complete working cycle, is, as we shall see, only one of the contributing causes to the serious operating conditions imposed upon horizontal engines.

PRESSURE DIAGRAMS FOR VERTICAL ENGINES

Figs. 1*A* and 1*B* apply to a vertical four-cycle trunk piston engine of a cylinder size somewhat larger than that on which Mr. Daugherty's figures are based. As may be readily seen, this difference in cylinder sizes is of little consequence, since the final result is a matter of relative values rather than absolute figures.

Fig. 1*A* shows in full heavy lines the indicator diagram developed into the four consecutive strokes of the complete working cycle. The pressures during the exhaust and suction strokes are so small (not exceeding $1\frac{1}{2}$ lb. sq. in. in a well-designed engine) that they could be just barely indicated. The inertia effect of each stroke is shown in heavy dashed lines. For vertical engines, especially larger units and moderate speeds, this inertia effect should be corrected for the weight of the reciprocating parts. Since this weight of course is constant, the correction consists in merely drawing a parallel to the inertia curve, as shown by the heavy full lines.

It will be noticed that in this particular case the correction amounts to just $\pm$ 10 per cent of the maximum inertia effect. In applying this correction it must be remembered that at the beginning of the downward strokes the weight reduces the inertia effect, while the opposite is true at the beginning of the upward strokes. Combining the corrected inertia effects with the absolute pressures of the indicator card produces the net forces acting in the direction of piston travel. These forces are designated by the lines enclosing the cross-sectional area. All pressures or forces in Fig. 1*A* are reduced to lb. sq. in. piston area; those tending to impart motion to the piston are plotted above the 0-line and are designated +, while those producing the opposite effect are designated — and are plotted below.

The side pressures resulting from the net piston forces are shown in Fig. 1*B*, those acting on one side of the cylinder are again designated + and are plotted above, while those acting on the opposite cylinder side are designated — and are plotted below the 0-line. The absolute value of these side pressures is given (this seems preferable over the presentation used by Mr. Daugherty, lb.sq.in. piston area, which is not representing any actual working conditions and is therefore misleading).

Throughout the expansion stroke the side pressures are positive, their maximum being 12,750 lb. On the following exhaust and suction strokes the side pressures first reach a

positive, then a negative maximum, the respective values being given on the diagram. On the compression stroke the side pressures are entirely negative, their maximum of 4660 lb. being but little higher than that of the exhaust and suction strokes, in spite of the great difference of work done in the cylinder. By integration of all the values above the 0-line we obtain a mean pressure of 2500 lb. acting along one side of the cylinder, while on the other side the mean pressure amounts to 1340 lb. Thus these side pressures are within 33 per cent of being equally divided between the two cylinder sides, and what is more important, at least once in every stroke this pressure reverses from one side to the other, there being a total of six reversals during a complete cycle of operation.

DIAGRAMS FOR HORIZONTAL ENGINES

Figs. 2*A*, 2*B* and 2*C* apply to a horizontal four-cycle engine of the same bore and stroke. Fig. 2*A* gives again the developed indicator card and the inertia effects; these latter do not require any correction here since in horizontal engines the weight of the reciprocating parts acts at a right angle to the direction of piston travel. Note how the resulting forces differ from those of the vertical engine in magnitude as well as location (point of reversal from + to — forces, which under certain conditions may be of considerable importance, as I expect to show in the near future).

Fig. 2*B* shows again the side pressures, with the connecting rod length the same as on the vertical engine. These side pressures are plotted about the abscissa *X-X*, pressures acting downwards being shown above *X-X* and designated +, while those acting upwards, tending to lift the piston, are —. To these side pressures must be added the weight of the reciprocating parts, which of course acts continuously downward. The true 0-line therefore runs parallel to the abscissa *X-X* at a distance equal to the weight of the moving parts. (The inertia effect of the swinging connecting rod, both in the vertical and horizontal engine, would not be sufficient visibly to affect the diagram.) All the values given to the diagram are measured from this actual 0-line.

Thus corrected it appears that with the exception of four very short intervals the side pressures are continuously acting downwards, their mean pressures during all four strokes being 4400 lb. It is very questionable whether the remaining negative pressures will be sufficient in the short time interval to overcome the friction at the piston rings and adhesion between piston and cylinder wall; in all probability the piston is continuously held in contact with the underside of the cylinder. This is even more likely to be the case where the connecting rod is made longer, as shown in Fig. 2*C*, where the length is increased by one crank over that in Fig. 2*B*. This increasing the connecting rod length not only has the effect of decreasing the maximum pressures, as pointed out by Mr. Daugherty; it also decreases the mean pressures to just about the same magnitude as the sum of + and — mean pressures of the vertical engine.

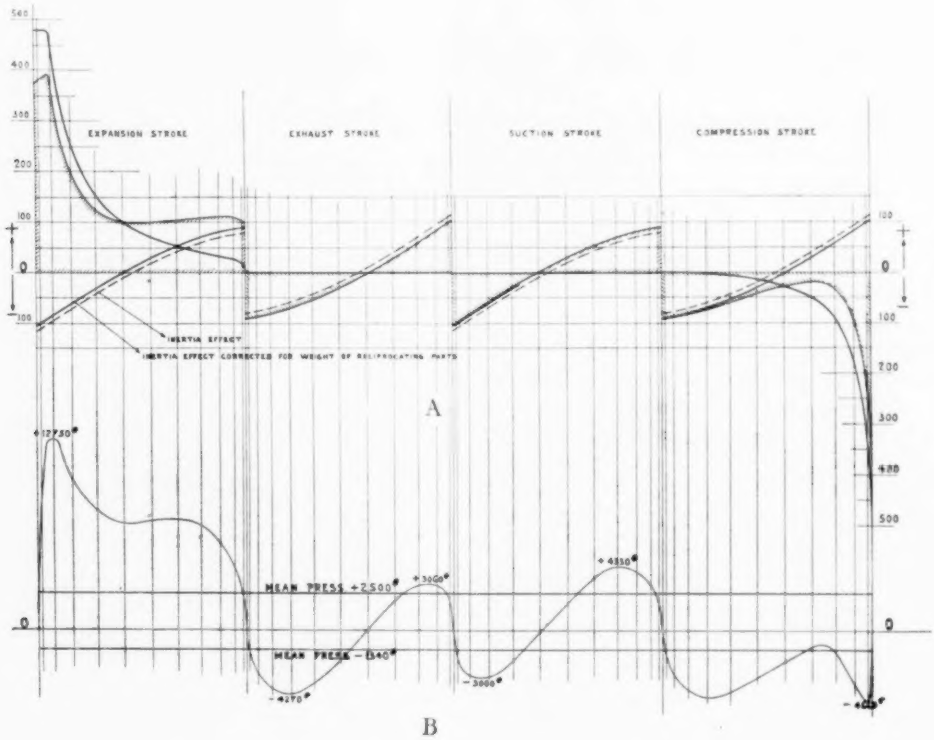

Fig. 1 Pressure Diagrams for Vertical Oil Engine

The friction work in both these engines would therefore appear to be practically the same. There is this fundamental difference, however, that in vertical engines the side pressures cause the piston continuously to shift its contact from one cylinder side to the other, while in horizontal engines approximately the same or larger side pressures are keeping the piston continuously pressed down against the same side of the cylinder. The significance of this shifting of pressures and contact is clearly shown in Mr. Daugherty's description of the superior process of lubrication in the main bearings of horizontal engines, in the last paragraph on page 786 of the Journal. (Incidentally, this applies to a dot to the bearings of vertical engines, to prove which it is only necessary to remove the bearing caps from an engine in operation and

watch the results.) What has been found to be necessary on bearings with their ideal rubbing surfaces and operating conditions in general, certainly is of no less importance for pistons, where cast iron slides on cast iron at a maximum rubbing speed three times as high as in bearings, and at temperatures which would prove disastrous to the latter.

In view of the foregoing facts, the "feature of superiority" attributed to the single oil feed on the upper side of horizontal cylinder does not become so apparent; in fact, noticing that the oil has to find its way by gravity to the under side of a surface continuously under pressure, it looks to be decidedly a feature of inferiority. At best it seems little else than capillary attraction which would permit a trace of oil to get to the underside of the piston during the short intervals of light pressure against the cylinder wall; this, however, is far from having the lubricating system under such control as to meet varying operating conditions, and which is so thoroughly accomplished on vertical engines. In the latter the oil is not only more evenly supplied, but the continuous change of contact of the piston from one cylinder side to the other spreads the lubricant over the whole circumference and ensures the maintenance of an even oil film. The friction work is thus materially reduced and what remains is distributed over twice as large a surface as in horizontal engines. It is entirely due to this increased friction work between piston and cylinder walls that the mechanical efficiency of horizontal engines is lower than that of vertical ones. This friction work is converted into heat and must be dissipated through the adjoining walls. The amount of heat which from this source might have to be dissipated through the underside of piston and cylinder walls of a horizontal engine can easily run up to from 30 to 40 per cent of that transmitted through this same channel from the combustion chamber.

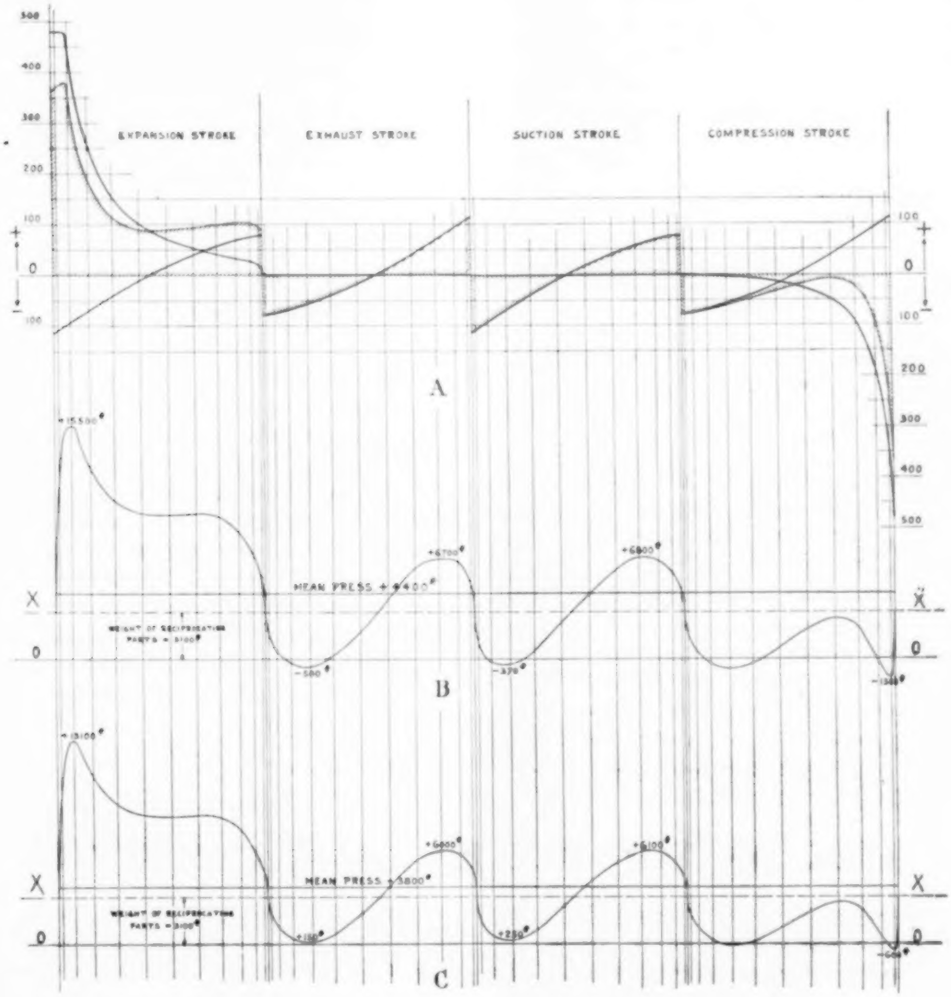

FIG. 2 PRESSURE DIAGRAMS FOR HORIZONTAL OIL ENGINE

STRESSES IN CRANKSHAFT

Mr. Daugherty has failed to give positive reasons, in figures or graphically, why there should be a "better distribution of stresses on the crankshaft and main bearings" of horizontal engines than of vertical engines. Without desiring to go into a useless word argument, I am, however, prepared to prove that the opposite is true. As in the case of side pressures, it is not sufficient merely to determine the maximum load by means of some ready baked formula. The question of distribution of stresses in crankshafts and bearings involves a careful analysis of the affected parts for rigidity and magnitude of deflections, which may very easily greatly augment the stresses set up. If Mr. Daugherty is willing to present in these pages an exposition of his method of computation for a horizontal engine, including the underlying facts as to dimensions and weights to facilitate check-

ing, I shall be glad to follow suit with the nearest size vertical engine on which I am able to get the necessary information. Such a presentation given for a twin cylinder engine would be particularly interesting, since on this type it can be shown even better than on a single cylinder unit how unfavorable the conditions are as compared with vertical engines.

Of all the arguments that Mr. Daugherty has presented in favor of the horizontal engines, that of "easy survey and convenient attendance" is the only one I regard as having merit. Although the valves and valve gear are at least as accessible on vertical engines as on any horizontal one brought out so far, particularly in the larger sizes, the necessity for first having to mount a platform in order to get at these, as well as at the fuel pumps, or for starting and stopping, is a feature which it would seem desirable to do away with on vertical engines. An engine with this in view, as well as containing a number of other features to make the vertical type better adapted to American conditions, both from the operating and particularly the manufacturing standpoint, is being brought out by myself at the present time. I am merely mentioning this now to give Mr. Daugherty time for the preparation of new weighty arguments in favor of horizontal engines.

H. R. Setz.

St. Louis, Mo.

ENGINEERING SOCIETIES AND PUBLIC AFFAIRS

To the Editor:

I noted with interest the comments of Mr. Henry Hess on the relation of engineering societies to public affairs, on page 641 of the August issue of The Journal. With due recognition of the strength of the "consultant" attitude, is it not pertinent to inquire whether the "wait-till-they-ask-me" position does not also have its weakness?

Admittedly this is the safest course from the engineers' standpoint, but suppose the engineer is not consulted. To get things done it is often advisable to step down from the pedestal of dignity and go to work. Whether or not there is a real loss of dignity is determined largely by *what* work is undertaken and *how well* it is done. If our engineering societies are afraid they cannot measure up to the requirements of such a progressive attitude, then by all means let us stay on our pedestal where we will not encounter the difficulties of constructive, aggressive work.

There is much talk about the engineer not getting the recognition that his ability deserves. We can sit back and tell each other that the crying need in our community affairs is the more active participation of engineers with their analytical and constructive abilities. I venture to say that the fundamental cause of the condition referred to is this same dignified, "standpat" attitude which leaves the field to the professional politician.

If our engineering societies do not have sufficient wisdom in the management of their affairs to guard against misuse of their powers when taking up constructive community activities then let them stay out or improve their managements.

Anything worth having is worth working for. If we would have the standing in the community our ability warrants, we must perform the work that this same ability fits us for. The same is true of the society as of the individual.

W. Herman Greul.

New York, N. Y.

OUR INDUSTRIES AND CITIZENSHIP

To the Editor:

Referring to Mr. Glynn's letter on page 644 of the August issue of The Journal, I think the salvation of our Industries and Citizenship lies in the direction of scientific management, under which all factories become in effect laboratories for the education of employees. There is no education comparable in efficiency and thoroughness with that of "learning by doing." You cannot learn to ride a bicycle, for instance, by reading a book, nor can you do anything worth while in any direction until you take hold of the work and apply yourself to it; and, to obtain the best results, every worker must have the incentive and the ambition to excel in what he undertakes.

Wilfred Lewis.

Haverford, Pa.

WORK OF THE BOILER CODE COMMITTEE

The Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, Mr. C. W. Obert, 29 West 39th St., New York City.

Interpretation meetings of the Boiler Code Committee have been continued through the summer months, two meetings having been held, one July 27, and another August 24, for the consideration of inquiries received concerning the rules in the Boiler Code. The interpretations rendered in the Cases there considered have been passed by the Council and are published below. The interpretations rendered by the Boiler Code Committee have been published in the January, April, and September, 1916, issues of The Journal, as follows: January issue, Cases Nos. 1-36 inclusive; April issue, Cases Nos. 45, and 47-48 inclusive; September issue, Cases Nos. 49*a* and 59-88 inclusive.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of the Society for approval, after which it is issued to the inquirer and simultaneously published in The Journal, in order that anyone interested may readily secure the latest information concerning the interpretation.

Below are given the interpretations of the Committee as approved by the Council on October 13, 1916, in Cases Nos. 86 and 89-103 inclusive. In this report, as previously, the names of inquirers have been omitted.

Case No. 86

Inquiry: (a) How is the lowest permissible water level determined under Pars. 291-294 of the Boiler Code, for

vertical fire tube boilers both with and without submerged tube sheets?

(b) Are fire engine boilers subject to the requirements of the Boiler Code, and if so, what should be the lowest water level?

Reply: (a) With vertical fire tube boilers where the top tube sheet forms the top of the boiler, the lowest permissible water level shall be one-third the length of the tubes, measured from the crown sheet or the top of the lower tube sheet. With vertical fire tube boilers constructed with submerged tube sheets, the lowest permissible water level shall be the top of the upper tube sheet. According to Par. 291, the lowest visible part of the water glass or the lowest gage cock shall be not less than 2 in. above the lowest permissible water level.

(b) Fire engine boilers are necessarily of highly special construction and more of the general type of flash boilers and are not absolutely subject to all the requirements of the Code. Unless special provision is made to keep the water above the fire box crown sheet other than by the natural water level, the lowest gage cock should be at least 5 in. above the top of the fire box crown sheet.

Case No. 89

Inquiry: Will it be desirable for a State, in administering the A.S.M.E. Code, to submit all inquiries that arise concerning the rules to the Boiler Code Committee for interpretation?

Reply: Where there is a question respecting the interpretation of the Code, or where constructions apparently are not covered by the Code, it will be most desirable to have the matter referred to the Boiler Code Committee. Unless this procedure is followed, the aim to obtain uniformity in the application of the Code will be defeated. Naturally, there will be inquiries where it is self-evident that there can be no question as to how the Code should be interpreted, and such inquiries evidently need not be referred to the Boiler Code Committee. The Boiler Code Committee desires to coöperate to the limit of its ability in assisting in the application of the Code, and will take pleasure in considering all matters where there is any question of doubt that may be brought up to it by the various states and municipalities that adopt the Code.

Case No. 90

(In the hands of the Committee)

Case No. 91

Inquiry: Will it not be desirable to require the stamping of the allowable working pressure on all boilers built to the A.S.M.E. Code as is required by the rules for some localities?

Reply: To make any disposition of this suggestion would involve an addition to the Code. The Boiler Code can be changed only after suggestions for changes are considered at a hearing before the Committee, where all interested parties may be heard. The Committee recommended in the Code that hearings to consider revisions be held at least once in two years, and the time for the first hearing is now near at hand.

Case No. 92

Inquiry: In the cone top of a vertical submerged tubular boiler that under Par. 231 requires staying as a flat surface, where should the stays be located, and what length should be taken for calculating the pressure allowable?

Reply: Where a cone top requires staying over a portion of its surface as permitted by Par. 231, the top row of stay bolts must be at a point where the cone top is not over 30 in. in diameter.

In calculating the pressure permissible on the unstayed portion of the cone, the vertical distance between the horizontal planes passing through the center of the rivets at the cone top, and through the center of the top row of stay bolts shall be used as L in Par. 239, and D in that paragraph shall be the inside diameter at the center of the top row of stay bolts.

Case No. 93

Inquiry: Exemption is requested from Pars. 186 and 187 of the A.S.M.E. Code, which apply to the welding of boiler joints, where the electric metal-electrode, or so-called "pencil-type" of autogenous welding is used, as this process is claimed to be greatly superior to any form of gas welding.

Reply: This inquiry is answered by the reply made in Case No. 80, as follows:

The Committee has since its inception had under constant observation all sorts of welding of pressure vessels, and has gone so far as to ask some of the welding experts of this country to write papers for the Society to bring out further information regarding this particular process. Suggestions for changes will be considered at a hearing before the Committee, where all interested parties may be heard. The Committee recommended in the Code that hearings to consider revisions be held at least once in two years, and the time for the first hearing is now near at hand.

Case No. 94

Inquiry: As there seems to be some misunderstanding of the interpretation rendered in Case No. 43, an interpretation is requested of the application of Par. 223 as interpreted by Case No. 43, to the details of construction of diagonal boiler braces.

Reply: This inquiry is answered by the reply made in Case No. 69, as follows:

In previous cases of this kind (See Case No. 29) the Committee has said that all braces used in A.S.M.E. Code boilers should conform to the Code in every detail. Difficulty has been experienced in interpreting Par. 223, which applies to such braces, and the Committee therefore submits the following to explain how this paragraph should be applied:

The requirements in Par. 223 are based on the "required cross-sectional area of the brace." To apply Par. 223, proceed as follows:

1 Determine the "required cross-sectional area of the brace" by first computing the total load to be carried by the brace, and dividing the total load by the values of stresses for unwelded stays given in Table 4.

2 Design the body of the brace so that the cross-sectional area shall be at least equal to the "required cross-sectional area of the brace" for unwelded braces. Where the braces are welded, the cross-sectional area at the weld shall be at least as great as that computed for a stress of 6000 lb. per sq. in. (See Table 4.)

3 Make the area of pins to resist double shear at least three-quarters of the "required cross-sectional area of the brace."

4 Make the combined cross-section of the eye at the side of the pin (in crowfoot braces) at least 25 per cent greater than the "required cross-sectional area of the brace."

5 Make the combined cross-sectional area of the rivets at each end of the brace at least 1¼ times the "required cross-sectional area of the brace."

6 Design each branch of a crowfoot to carry two-thirds the total load on the brace.

7 Make the net sectional areas through the sides of the crowfeet, tee irons, or similar fastenings at the rivet holes at least equal to the required rivet section, that is, at least equal to 1¼ times the "required cross-sectional area of the brace."

8 The cross-sectional areas through the blades of diagonal braces where attached to the shell of the boiler shall be at least equal to the required rivet section, that is, at least equal to 1¼ times the "required cross-sectional area of the brace."

Case No. 95

Inquiry: (*a*) What value of C should be used in the formula in Par. 199 to determine the thickness of tube sheets and spacing of staybolts or braces, where the staybolts or braces

are screwed through the plate, or made a taper fit and the heads formed on the staybolts or braces before installing them and not riveted over, said heads being made to have a true bearing on the plate, and where the diameters of the heads are not less than 1.4 times that of the ends of the staybolts or braces?

(*b*) In Par. 203, can *C* be taken in the proportion of 160 to 135 for forms of stays which allow a greater value of *C* than 135, based on the pitch measured between stays?

Reply: (*a*) The value of *C* should be 150.

(*b*) Yes. The maximum spacing between the rivet surface of the shell and lines parallel to the surface of the shell passing through the centers of the stays or braces shall be determined by the formula in Par. 199, using for *C* the value for regular spacing multiplied by the ratio of 160 to 135.

Case No. 96

Inquiry: An interpretation is requested relative to the actual number of stamps required under Par. 36 of the Boiler Code. Is it essential that the plate manufacturer's stamp appear in three places on the plate if the physical and chemical properties meet the requirements of the Code?

Reply: It is the intent of the Code that one of the several stamps be visible on each sheet after the boiler has been fabricated, which is evidenced by the fact that the word "stamp" in the last line of Par. 36*a* is in the singular. Where the plate manufacturer has placed the stamp or stamps on the plate in an insufficient number of places or in improper places, such plates may be restamped by the plate manufacturer, or his authorized agent, so that at least one stamp per plate shall be visible after the boiler is completed.

Case No. 97

Inquiry: (a) Where can the manhole required by Par. 264 of the Boiler Code be located in a Scotch type boiler with dome, that has no available space in the heads or shell outside the dome?

(b) An interpretation is requested of Par. 194 of the Boiler Code relative to a dome larger than 24 in. with the joint lap-riveted and under a working pressure of 100 lb.

(c) Referring to the requirement of the Boiler Code for reinforcements for threaded openings to give the proper number of threads, is there an exception in the case of water column connections?

Reply: (a) Relative to the location of the manhole, this is answered by Par. 264 of the Boiler Code, which permits a manhole in the head of the dome. Make the opening in the shell directly under the dome sufficiently large for access, and reinforce such opening in the shell with manhole frame as called for in Par. 261.

(b) With regard to the riveting of domes, attention is called to the interpretation rendered in Case No. 75, which states: "The intent of Par. 194 is that all domes 24 in. or over in diameter shall have butt and double strap longitudinal joints irrespective of the pressure used."

(c) With respect to the reinforcements of openings for water column connections, there is no exception in the Code to the number of threads required in openings for pipe fittings.

Case No. 98

Inquiry: (a) Is it permissible under Par. 272 of the Code to use a pop valve with 0.15 in. lift, basing the capacity on 0.15 in. lift and replacing a Code valve larger than this valve having the maximum discharging capacity as given in the table?

(b) Is it permissible with a 500 h.p. water tube boiler having 5000 sq.ft. of heating surface that will evaporate 30,000 lb. of water per hr. to use at 100 lb. pressure, six 3 in. pop valves (bevel seat) lifting 0.15 in., each having a discharge capacity of 5660 lb. of steam per hr.?

(c) Is it permissible to increase by 40 per cent the maximum discharge capacity as given in tables in the Code when using flat seat pops and may six 3 in. flat seat pops be used as outlined under Inquiry (b)

Reply: (a) According to Par. 274, if the marked relieving capacity of the valve exceeds that given in Table 8 of the Boiler Code, the maximum relieving capacity given in Table 8 governs in determining the minimum capacity of safety valve or valves to be placed on a boiler. The maximum capacity given in Table 8 for a 2½ in. bevel seat pop valve at 100 lb. pressure is 2516 lb. per hr.

(b) A water tube boiler with 5000 sq. ft. of heating surface evaporating 30,000 lb. of water per hr. at 100 lb. pressure will require at least eight 3 in. bevel seat pop safety valves.

(c) It is permissible to increase the maximum discharge capacity given in Table 8 by 40 per cent when using flat seat pop safety valves, provided the flat seat valves have the same lift as that given in the table, and six 3 in. flat seat valves will be sufficient for the boiler referred to under (b).

Case No. 99

(In the hands of the Committee)

Case No. 100

Inquiry: (*a*) Does Par. 264, which requires a manhole in the front head below the tubes of a horizontal return tubular boiler apply to the regular brick set type of boiler only, or to portable types of boilers also?

(*b*) Is it permissible where two or more safety valves are used on a boiler, to attach each safety valve directly to the boiler by a forged steel flange?

(*c*) In the hands of the Committee.

Reply: (*a*) Par. 264, respecting the location of a manhole in the front head below the tubes, applies to horizontal return tubular boilers only.

(*b*) In the use of two or more safety valves on a boiler, each may be attached directly to the boiler by a forged steel flange.

(*c*) (In the hands of the Committee).

Case No. 101

Inquiry: What dimensions are permissible under the A.S.M.E. Boiler Code for brass or bronze pipe fittings?

Reply: In the absence of any other special standard, the Boiler Code Committee endorses the use of brass or bronze fittings designed for a factor of safety of five and with diameters of bolt circles, and numbers and sizes of bolts to correspond with those given in Tables 15 and 16 of the Boiler Code.

Case No. 102

Inquiry: Is welding by the acetylene process permissible for the welding of heads and connecting nipples on headers used for furnaces of the down-draft type?

Reply: The Committee has since its inception had under constant observation all sorts of welding of pressure vessels and has gone as far as to ask some of the welding experts of this country to write papers for the Society to bring out further information regarding this particular process. Suggestions for changes will be considered at a hearing before the Committee, where all interested parties may be heard. The Committee recommended in the Code that hearings to consider revisions be held at least once in two years and the time for the first hearing is now near at hand.

Case No. 103

Inquiry: Under Par. 29*a* of the Code, should deductions in the percentages of elongation be made pro rata or in steps to correspond to the increase in size of ⅛ in. above a thickness of ¾ in.?

Reply: It is the opinion of the Committee that deductions in the percentages of elongation should be made in steps as specified in the Code.

Society Affairs

Engineering Survey

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

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Terms expire December 1917

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Constitution and By-Laws, Jesse M. Smith
Standardization, Henry Hess

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American Association Advancement of Science
American Society for Testing Materials, Modification Briggs Standard for Pipe Threads
Classification of Technical Literature
Conference Committee on Electrical Engineering Standards
Conference Committee of National Engineering Societies
Conference Committee on Cooperation in American Engineering Standards
Conference Committee to Determine Cost of Electric Power
Conservation
Engineer Reserve Corps
Engineering Foundation
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- Sub-Committee on Worm Gearing, Fred A. Halsey

Sections, Elliott H. Whitlock
Standard Flanges and Pipe Fittings, Henry G. Stott
Standards for Graphic Presentation, Willard C. Brinton
Standards for Machine Tools
Student Branches, Frederick R. Hutton
Tellers of Election, Robert H. Kirk
Tolerances in Screw Thread Fits, L. D. Burlingame

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Worcester, Paul B. Morgan, Edgar H. Reed

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[1] A complete list of the officers and committees of the Society will be found in the Year Book for 1916, and in the July, 1916, issue of The Journal.

SOCIETY AFFAIRS

A Record of the Current Activities of the Society, its Members, Council, Committees, Sections and Student Branches; and an Account of Professional Affairs of Interest to the Membership

SECRETARY'S CHAT WITH THE MEMBERS

As a further development of the new National Defense Act, military education for college students, particularly the reserve officers training corps, was discussed by nearly a score of university and college presidents meeting with the officials of the U. S. War Department in Washington on Tuesday, October 17.

Besides President Howell, of Harvard University, and President Hadley, of Yale University, our own engineer-president, Dr. Drinker, of Lehigh University, participated in the conference. This movement will tie in the reserve corps of civilian engineers about which I have already spoken.

The outcome of this movement will probably be the assumption of a complete course in military drill by practically all the Land Grant Colleges and many of the other colleges in this country. President Wilson has announced the personnel of the Civilian Advisory Commission to the National Defense Council, as follows: Daniel Willard, President of the B. and O. Railroad; Samuel Gompers, President of the American Federation of Labor; Dr. Franklin H. Martin, of Chicago; Bernard Baruch, of New York; Howard E. Coffin, Mem.Am. Soc.M.E., of Detroit; and Dr. Hollis Godfrey, Mem.Am.Soc. M.E., president of Drexel Institute. The appointment of Mr. Coffin to represent Industries is a direct recogniton of his services and that of the engineering societies to the nation in the Industrial Census just completed.

Speaking of the importance of this work, Secretary of War Baker, in an address on September 26 before the Cleveland Chamber of Commerce, said of Mr. Coffin that he "has done perhaps the greatest service that has been done for America by any private citizen in the last fifty years."

The committee of five, of which the Secretary is secretary, appointed to report on a form of organization for a Scientific Civil Alliance to make permanent the organization of State Directors of the Industrial Census, made their report on Tuesday, October 17, at a meeting held in the rooms of the Society.

The Secretary recently addressed the public meeting of the City Planning Committee of the Cleveland Engineering Society, and took occasion to compliment that society and its public-spirited secretary on the many ways in which the society is serving the public. The national engineering societies have their duties to the nation, as in the census and reserve corps above mentioned, and the local societies and the branches have in turn their obligations to the locality which they serve, and, still further, the individual engineer must always be a good citizen, serving in all possible ways for the common good of his community.

The so-called "recognition" of the engineer will follow in direct proportion as he serves unselfishly the welfare of the public. The emphasis should always be on *service.*

Similar good movements to that at Cleveland are in progress in Atlanta, Minneapolis, St. Paul and San Francisco. The difficulty is, however, the desire to officially couple the name of the national society with regulation. If the branches of the Society can keep the two distinct, they will relieve the Council and themselves of embarrassment.

The proper scope of the local as well as the national societies is to furnish technical information in those realms where the society is a recognized authority, and to stop where the society ceases to have no more authority than others.

Calvin W. Rice,
Secretary

COUNCIL NOTES

A meeting of the Council was held on October 13. The following were present: D. S. Jacobus, *President;* J. Sellers Bancroft, John H. Barr, Arthur M. Greene, Jr., Henry Hess, Frederick R. Hutton, W. B. Jackson, Charles T. Main, H. de B. Parsons, Jesse M. Smith, John A. Stevens, Max Toltz, E. H. Whitlock, and Calvin W. Rice, *Secretary;* and by invitation Charles Whiting Baker, member of the Joint Conference Committee of the National Engineering Societies; H. L. Gantt, Chairman of the Committee on Meetings; I. E. Moultrop, chairman of the Publication Committee, and Herman Aaron, Esq., counsel for the Society.

Boiler Code Committee. Interpretations of this Committee Nos. 89 to 103, were approved with slight corrections and ordered published. They are published elsewhere in this issue of The Journal.

A Conference Committee to the Boiler Code Committee was created to consist of representatives of the states and municipalities that adopt the Code, and it was voted to invite each such state and municipality to appoint a representative to act on this committee. All discussions will be confined to the technical field of boiler construction and installation.

It was voted to send invitations to all interested parties to the proposed public hearing on the Boiler Code to be held during the forthcoming Annual Meeting of the Society.

Power Test Committee. Prof. R. H. Fernald and James W. Parker were appointed members of this Committee.

Sections. A Section was approved in New Orleans, La., to include all members residing within sixty miles of that city. W. B. Gregory, chairman; H. L. Hutson, secretary-treasurer; R. T. Burwell and E. W. Kerr were appointed as executive committee of the new Section.

A Section was also approved in Indianapolis, Ind., to include all members residing within sixty miles of the city and in Lafayette and Terre Haute.

Max Toltz was elected a member of the executive committee of the Minnesota Section, in place of Prof. W. H. Kavanaugh,

resigned because of removal from the territory of the Section.

Increase of Membership. C. B. Davis was appointed chairman of the Birmingham, Ala., sub-committee on Increase of Membership.

Section Affiliations. It was voted to appoint a committee, with E. H. Whitlock, Chairman of the Sections Committee, and the Chairmen of the Sections who have been in touch with plans for local organizations, to present a statement covering the rightful affiliations of the Sections with such organizations.

Junior and Student Prizes. Recommendations of the Committees on Award of Junior and Student Prizes by Junior-Members and by members of Student Branches, respectively, during the year ending June 30, 1915, were approved, and the prizes were awarded.

Coöperation in American Engineering Standards. An invitation was received from the American Institute of Electrical Engineers to appoint three representatives from our Society on a joint committee of the national engineering societies to consider ways and means of bringing about coöperation in American engineering standards, the representatives on this committee to report back to their respective societies.

The Committee on Standardization was empowered to appoint three of its members to represent the Society on this joint conference committee.

American Association for the Advancement of Science. President Jacobus was appointed to represent the Society on the council of this association, with W. B. Jackson, previous appointee.

Alterations to Building. Recommendations of the House Committee for the alterations required in the Society's rooms to carry columns through them for the additional stories to accommodate the Civil Engineers were approved.

Spring Meeting, 1917. The date of the Spring Meeting of the Society was fixed for May 22 to 25, 1917.

Biographies. It was voted that a Biographies Committee be appointed in connection with a plan to prepare or edit biographies of notable American engineers.

Communications. The U. S. Navy Department advised the Society of its formal adoption of the recommendations of The American Society of Mechanical Engineers for Machine Screw Standards.

The secretary of the John Fritz Medal Board of Award advised that the award had this year been made to Prof. Elihu Thomson, of Swampscott, Mass. The ceremonies of presentation of the medal will take place at a general meeting of the American Institute of Electrical Engineers, in Boston, on December 8, 1916.

CALVIN W. RICE,
Secretary.

OFFICERS OF THE SOCIETY VISIT CENTERS

PRESIDENT JACOBUS and Secretary Rice have just completed a tour to some of the centers at which members have under consideration the advisability of forming Sections, and have also been able to visit some of the Student Branches. They were gratified to find everywhere splendid interest in the affairs of the Society and a spirit of willingness to coöperate in its various activities.

The Secretary's first visit was to Meriden, Conn., where a meeting of members of the Society—the first gathering of mechanical engineers to be called in that vicinity—was held on October 3. Engineers were present from Wallingford, Middletown and Southington. The Committee in charge of the meeting was C. K. Decherd, chairman; R. S. Brotherhood, secretary; J. H. Hutchinson, George A. Horne, C. N. Flagg, Jr., and Frank Roundtree. The Meriden members are ambitious to form a permanent organization for holding regular meetings, and in this way develop the Society in that locality.

On October 16 the Secretary visited the Carnegie Institute of Technology Student Branch, Pittsburgh, and told of recent developments in the work the Society is undertaking, and outlined for them the part they are expected to take in promulgating the objects of the Society.

Proceeding to Cleveland on October 17, Mr. Rice met the Cleveland local committee at luncheon at the Cleveland Engineering Society, when F. A. Scott, Mem.Am.Soc.M.E., gave his views on the industrial preparedness movement.

At six p.m. the Secretary met the members of the Student Branch at Case School of Applied Science. The meeting was held at the Case Club, and a number of Cleveland members of the Society joined with the students in the meeting. Mr. E. H. Whitlock, Chairman of the Committee on Sections, Dr. Ambrose Swasey, Honorary Member and Past-President Am.Soc.M.E., Dr. C. S. Howe, Mem.Am.Soc.M.E., president of Case School, and Mr. F. W. Ballard, president of the Cleveland Engineering Society, were present.

In the evening the Secretary addressed a public meeting held in the rooms of the Cleveland Engineering Society under the auspices of the City Planning Committee of the Society.

Dr. Jacobus met Mr. Rice at Buffalo on October 18, and they participated in an informal luncheon given by a group of Buffalo members of the Society. Matters relating to Society affairs and to the engineering profession in general were discussed.

In the evening the members of the Buffalo Engineering Society joined our Buffalo Section at a formal dinner at the Hotel Statler. President Jacobus afterwards addressed the meeting on the relations existing between the parent Society and its Sections, and on coöperation between the Sections and local engineering societies and clubs. The Secretary described recent developments in the many broad movements in which engineers are participating and in which the Society is taking a leading part.

The next center visited was Erie, Pa., where active members have been considering the advisability of organizing a Section. These members organized a meeting which was held at the Hotel Lafayette, under the auspices of the Engineers' Society of Northwestern Pennsylvania, Mr. Hays H. Clemens, president. Mr. F. J. Wadsworth was instrumental in arranging the details which led up to this meeting.

Dr. Jacobus, Mr. Whitlock, and Mr. Rice were present at this meeting and explained the benefits which accrue to those members who are willing to contribute their time and energy to conduct a Section. They showed also how the establishment of an Am.Soc.M.E. Section tends to develop the local engineering organization because of the close coöperation it affords with vital engineering developments.

As a result of this meeting, the members at Erie are proceeding to petition the Council for the authority to conduct meetings.

Marked progress has been made by the members at Indianapolis, Lafayette and Terre Haute, Indiana, in their plans for coöperative meetings of all branches of engineers, and a

large and enthusiastic audience greeted Messrs. Jacobus, Rice and Whitlock at the organization meeting of the Indianapolis Section which was held on October 20.

At its October meeting the Council approved the recommendation of the Committee on Sections that an Indianapolis Section be authorized, and the Section is now established. All members residing at Lafayette, Terre Haute or within a radius of 60 miles of Indianapolis will be included in this Section, and the members at Rose Polytechnic Institute and Purdue University will constitute part of the organization. The manner in which the newest Section carried through its first meeting gives promise of rapid development.

From Indianapolis Mr. Rice proceeded to the Student Branch at the Kansas State Agricultural College, Manhattan, Kansas, where he was very graciously received by Prof. A. A. Potter and the undergraduate body. He was similarly entertained at the University of Kansas, Lawrence, Kansas, by the members of the Student Branch there and its Honorary Chairman, Prof. P. F. Walker. At both of these colleges Mr. Rice made addresses similar to those he made at the Carnegie Institute and at Case.

On the evening of October 23, the Secretary had the pleasure of meeting some of the active members of the Society in Kansas City who are looking forward to the establishment of a Section, and to them he explained the work which is being done by Sections and the great good resulting therefrom to the engineering profession and in turn to each individual member who takes part in Section activities.

Washington University Student Branch at St. Louis welcomed the Secretary on October 24.

Proceeding from St. Louis to Baltimore, Mr. Rice again met Dr. Jacobus, where they attended a meeting of the mechanical engineering students of Johns Hopkins University for the purpose of organizing a Student Branch. On October 25 they were present at an organization meeting held by the members of the Society in Baltimore and vicinity, when it was voted to file a petition to the Council for the establishment of a Baltimore Section. At this meeting a paper was read by Mr. W. L. DeBaufre, of the Naval Academy at Annapolis describing the work of the U. S. Naval Experiment Station there.

On his return journey to New York, the Secretary visited the recently established Student Branch at Bucknell College and also the Student Branch at the Pennsylvania State College.

JOINT SECTION MEETING TO BE HELD AT NEW LONDON

Boston, New Haven, New York and Worcester Sections and Providence Engineering Society to Visit Submarine Base and Engine Works There on November 11.

As The Journal goes to press plans are being perfected for an excursion which is unique in the annals of the Society. In view of the current interest in submarines, and of the expressed desire of a number of members to inspect a plant where submarine engines are built, special permission has been secured by the Society for a party of members to visit the works of the Electric Boat Company at New London, Conn., on Saturday afternoon, November 11, and arrangements made for the participation of the Sections at Boston, New Haven, New York, Worcester, and the Providence Engineering Society, affiliated with our Society, in the trip.

Some of the largest Diesel Engines manufactured in this country have been designed and built at the Electric Boat Company's plant, and the party will have the unusual opportunity of witnessing the processes and methods of construction of this class of prime mover for submarine service. A special test will be run on a high-power 8-cylinder, 4-cycle Diesel Engine. A large number of submarine and other oil engines will be seen in various stages of construction, and such operations as the boring of torpedo tubes, cylinders and other equipment for submarines examined.

Through the courtesy of Rear-Admiral A. W. Grant, in command of the submarine arm of the United States Navy, the visitors will be given a special exhibition at close range of several submarines submerging, and will also be shown a surface attack by a submarine. This exhibition will take place at the submarine base and training school, near New London.

SCHEDULE

Boston members will leave South Station on Train No. 7, at 8:30 a.m. on Saturday, November 11. Those coming from Providence will board this train at 9:36 a.m., and these contingents will arrive at New London at 11:13 a.m.

Worcester members will leave on Train No. 745 at 8:36 a.m., arriving at New London at 10:58 a.m.

The New York party will leave Grand Central Terminal at 8:31 a.m. on Train No. 8. This train will leave New Haven at 10:30 a.m. and arrive at New London at 11:39 a.m.

Each group will, upon arrival, proceed directly to the Mohican Hotel, where luncheon will be served promptly at 11.45 a.m., enabling the party to leave for the plant of the Electric Boat Company promptly at 1:00 p.m. The inspection trip through this plant will require about one and a half hours.

The party will then be taken out into the Sound, where the submarine exhibit and attack will take place.

The party will return in time to make one of the following connections:

For Boston and Providence.

Leaving at 4:07 and 6:00 p.m. and arriving at Boston at 7:00 and 8:43 p.m. respectively.

For New Haven and New York.

Leaving at 3:57 and 5:41 p.m. and arriving at New York at 7:11 and 8:45 p.m. respectively.

For Worcester.

Leaving at 4:20 p.m. and arriving at Worcester at 8:00 p.m.

Members of the Society residing within radius of New London and not receiving a personal invitation to this meeting but seeing this announcement are cordially invited to participate.

Members of the American Society of Civil Engineers, the American Institute of Electrical Engineers, the American Institute of Mining Engineers, the Boston Society of Civil Engineers, the Brooklyn Engineers Club, the New York Engineers Club, the Providence Engineering Society, the Philadelphia Engineers Club, the Engineering students at Brooklyn Polytechnic Institute, Brown University, Columbia University, Massachusetts Institute of Technology, New York University, Stevens Institute of Technology, Worcester Polytechnic Institute, Yale University and other organizations of engineers living near New London, will also be welcomed.

THE THIRTY-SEVENTH ANNUAL MEETING, NEW YORK CITY, DECEMBER 5 TO 8

THE program of the thirty-seventh Annual Meeting of the Society, to be held in the Engineering Societies Building, New York, December 5 to 8, 1916, is announced below in as complete a form as is possible at this early date.

No less than eleven professional sessions have been arranged, with papers on similar subjects grouped in so far as practicable. This large number of sessions and the great variety of topics are the result of many months of work on the part of the Committee on Meetings and its sub-committees.

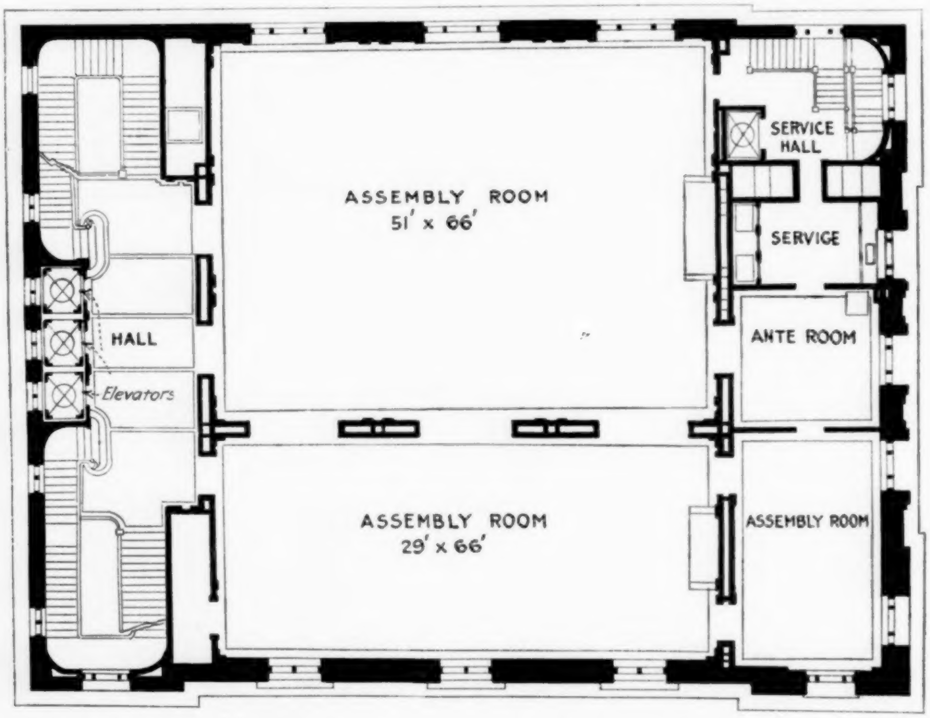
Elsewhere in this issue advance publication is made of a number of the papers to be presented and discussed, and others will follow in the next issue of The Journal. The papers are published in the form of abstracts, prepared in collaboration with authors and as complete and comprehensive as possible. Work on the printing of the complete papers in pamphlet form has been proceeding satisfactorily, and copies of any of these papers will be sent to members of the Society gratis upon application in advance of the meeting.

In view of these special efforts on the part of the Committee on Meetings and the Publication Committee to get the material of the papers in the hands of every member well in advance of the meeting, it is anticipated that the opportunity for contributing discussion will be widely taken advantage of.

The first Annual Meeting papers printed in this issue are those selected for presentation at one or other of the three Miscellaneous Sessions. These are the papers not secured by sub-committees, but presented to the Society directly by their respective authors.

These are followed by papers on valuation, which the Committee on Meetings has taken special pains to secure in order that such live subjects as appraisal of industrial property and industrial vs. public utility valuation may be discussed at a general meeting of the Society for the purpose of bringing out facts of value to engineers.

A Safety Code for Cranes to be presented by the Sub-Committee on Protection of Industrial Workers is published in this issue. The field of work of this committee is a large one, and is also an important one since, through this committee, the Society is endeavoring to effect an approach to uniform requirements in the matter of safeguards. The committee coöperates in its activities with state bureaus, insurance interests, organized societies, departments of industrial concerns and individuals, and has already discussed a number of standards.



Plan of Fifth Floor of Engineering Societies Building, New York, Showing Alterations for Social Functions of Founder Societies

The Sub-Committee on Gas Power will have charge of an important session, and two of its papers are published this month.

A strong feature of the meeting will be the session in charge of the Sub-Committee on Railroads. This committee is a very representative one, and at the sessions at general meetings in its charge a large amount of valuable material has been brought out. Two of this committee's papers are included in this issue.

The remaining Annual Meeting paper published this month is one of the three papers contributed by the Sub-Committee on Textiles. It reports the results of an important investigation upon the transmission of heat through window frames in mill buildings.

Papers to be presented at the Machine Shop Session and the session in charge of the Boiler Code Committee, as well as the remaining papers of the sessions noted above, will be published next month.

ENTERTAINMENT FEATURES

As usual, the social features of the meeting will be opened with the president's reception on Tuesday evening. This will follow Dr. Jacobus' presidential address in the Auditorium, and instead of being held in the Society's rooms on the eleventh floor, which have long since been inadequate for the purpose, will be held on the fifth floor, where with the alterations now in progress there will be splendid provision for such affairs.

The Engineering Societies Building has always lacked suitable accommodations for the social functions of the Founder Societies. The larger room on the fifth floor was not large enough for such functions and the floor was not suited for dancing. For some time there has been under consideration the arranging for the two assembly rooms on this floor to be thrown together and the laying of a hard wood polished floor in both. This improvement was agreed upon, and is now being carried out, and will be completed by the time of the Annual Meeting.

It was not feasible to make the partition between the two rooms entirely removable on account of the ventilating shafts and the necessity of having nearly sound-proof isolation of the two rooms when they are used independently, so the three double doorways are being increased to twice their former width as indicated on the accompanying plan. This will give ample means of communication between the two rooms for such purposes as dances, receptions and reunions. Any meetings that require the seating capacity of the two rooms combined will still be held in the Auditorium.

In addition to the president's reception, the two luncheons, Wednesday and Thursday noon, the smoker on Wednesday night, and the dance and reunion following the lecture on Thursday evening, will also be held on this newly-adapted fifth floor. It is not a little satisfaction to the committee in charge of the social arrangements that it will be possible this year for the first time to hold all of the Annual Meeting social events in the Engineering Societies Building.

TENTATIVE PROGRAM

Tuesday Evening, December 5

Presidential Address and Reception

President's address on the Relation of Education to Engineering, by Dr. D. S. Jacobus, President of the Society. This will be followed by the annual report of the Tellers of Election of Officers, the introduction of the President-elect, and a reception to the President, President-elect, ladies, members and guests. This gathering will be informal.

Wednesday Morning, December 6

Opening Session

Business Meeting.

Reports of the Council, Standing Committees and Special Committees, Constitutional Amendments and new business.

Award of Junior and Student Prizes.

John E. Sweet Memorial

Following the regular business of this session, there will be memorial exercises in honor of the memory of John E. Sweet, Past-President, Honorary Member and founder of the Society.

Miscellaneous Session

The Proportioning of Surface Condensers, George A. Orrok

The Testing of House-Heating Boilers, L. P. Breckenridge and D. B. Prentice

Water for Steam Boilers—Its Significance and Treatment, Arthur C. Scott and J. R. Bailey

Industrial Safety Session

Under the auspices of the Sub-Committee on Protection of Industrial Workers

Report on Safety Standards for the Operation of Cranes.

Wednesday Afternoon

Miscellaneous Session

The Utilization of Waste Heat for Steam Generating Purposes, Arthur D. Pratt

Graphic Methods of Analysis in the Design and Operation of Steam Power Plants, R. J. S. Pigott

Power Plant Efficiency, Victor J. Azbe

Textile Session

Under the auspices of the Sub-Committee on Textiles

Heat Transmission Through Various Types of Sash, Arthur N. Sheldon

Other papers will be presented on the question of moisture and humidity in the textile industry; and on the effects of vibrations in textile mill buildings.

Machine Shop Session

Under the auspices of the Sub-Committee on Machine Shop Practice

This session will be devoted to the discussion of papers on the standardization of machine tools and on a classification of machine shop practice and a proposed plan of work of the Sub-Committee on Machine Shop Practice.

Wednesday Evening

Smoker

The success of last year's smoker has decided the repeating of this form of entertainment for Wednesday evening. Entertainment will be provided, and a feature will be a short talk by Frank B. Gilbreth, Mem.Am.Soc.M.E., on his experiences in Europe during the war.

Thursday Morning, December 7

Valuation Session

It is expected that this session will continue both morning and afternoon.

Accurate Appraisals by Short Methods, J. G. Morse

Productive Capacity a Measure of Value of an Industrial Property, H. L. Gantt

Other authors will present papers on the relation between industrial valuation and utility valuation; on the interest of the public in valuation; on the relation between perpetual inventory value and appraisal value, and on amortization and depreciation.

Thursday Afternoon

Besides the continuation of the Valuation Session, there will be a Gas Power Session.

Gas Power Session

Under the auspices of the Sub-Committee on Gas Power

A Gas Producer for Bituminous Coal, O. C. Berry

Commercial Sampling and Gas Analysis, P. W. Swain

An Investigation of the Internal-Combustion Engine as Applied to Traction Engines, A. A. Potter and W. A. Buck

The Ratio of the Specific Heats and the Coefficient of Viscosity of Natural Gas from Typical Fields, Robert F. Earhart.

Illustrated Review of the Werkspoor Marine Diesel Engines, Thomas O. Lisle

Thursday Evening

Lecture and Annual Reunion

The Committee is making arrangements for a popular lecture to be given in the Auditorium on Thursday evening.

Following the lecture, the members and guests are invited to adjourn to the fifth floor of the Engineering Societies Building for the annual reunion and dance.

Friday Morning, December 8

Miscellaneous Session

The Impact Tube, Sanford A. Moss

Heat Treatment of Wrought Iron Chain Cable, F. G. Coburn, W. W. Webster and E. L. Patch.

The Flow of Air and Steam Through Orifices, Herbert B. Reynolds

Railroad Session

Under the auspices of the Sub-Committee on Railroads

Clasp Brakes for Heavy Passenger Equipment Cars, T. L. Burton

Mechanical Design of Electric Locomotives, A. F. Bachelder

Steam Boiler Session

Under the auspices of the Boiler Code Committee

An Analysis of the Working Parts of Safety Valves Met with in Marine Practice, with Suggestions for Repairs and Improvements, E. F. Maas

The Talbot Boiler, Paul A. Talbot

Friday Afternoon

Public Hearing by the Boiler Code Committee.

Saturday Morning, December 9

Public Hearing by Boiler Code Committee continued.

PLAN OF ACTIVITIES FOR THE SEASON 1916-17

Below is a continuation of the announcement in the last issue of The Journal, of the proposed activities for the season of Sections and Student Branches. At some of the colleges where the work of the term in the engineering department does not begin until the middle of October, the opening meeting of the Student Branch has not yet been held, and information regarding plans for the year has not come to hand.

SAN FRANCISCO SECTION

The San Francisco Section, through C. F. Braun, Secretary, reports that the coming season will be a really active one. In order to get the members together an informal smoker was held at the Engineers' Club during the first week of October.

In the fourth week of October the Section held a joint meeting with the A.I.E.E. Some of the members of the latter section presented papers on the Propulsion of Ships.

On November 16 a second joint meeting with the A.I.E.E. will be held, and W. W. Thompson will present a paper on The Trumbull Process of Refining Oil. Another social gathering is also planned for about the 26th of the month.

In the first week of December the section will hold a meeting at which W. J. Davis, Mem.Am.Soc.M.E., will present a paper on Turbine Blowers.

At a meeting to be held in February the Chairman, F. W. Gay, will present his paper on Engineering Economics of Partial Construction.

Besides these above meetings two other formal meetings and three smokers will be held during the season; at each of the latter some subject will be discussed informally.

Mr. A. C. Paulsmeier, Mem.Am.Soc.M.E., has signified his willingness to serve on the local committee and one other member will also be appointed on this committee, to fill vacancies caused by the resignations of Messrs. Terwilliger and Meredith. E. A. Rogers will act as Section Correspondent.

NEW HAVEN SECTION

The New Haven Section will follow its previous plan of holding two meetings during the season with afternoon and evening sessions and a dinner between them. The first of these meetings will be held on Wednesday, November 15, in the Hammond Mining Laboratory when the subjects of Applied Metallography, Prof. C. H. Mathewson and Testing of Metals, Prof. William Kent Shepard, will be presented. These papers will be followed by discussion. Following this session dinner will be served in the hall of the Yale Dining Club. The evening session will be held in the Mason Laboratory and two papers will be presented and discussed. The first of these is Recent Developments in Time-Study Devices, by Frank B. Gilbreth, Mem.Am.Soc.M.E., and the second, Processes of Facsimile Reproduction with demonstrations, by Samuel J. Berard, of the Mechanical Engineering Department of the Sheffield Scientific School. The local membership of the Section has increased greatly and interest in the Society is very keen. The Section has the coöperation of the Sheffield Scientific School and the service of its faculty on the Section Committee.

STUDENT BRANCHES

The *University of Colorado Student Branch* plans to hold two meetings each month during the school year. One meeting each month will be in charge of the students, and at the other professional men will be invited to speak.

The program for the year will include a trip to the smelting works at Pueblo, at least two trips to large plants in Denver, besides visits to sugar plants and power stations around Boulder.

The Branch held its first meeting on October 4, and an account of this is given elsewhere in this issue.

The *State University of Iowa Student Branch* will also hold semi-monthly meetings throughout the college year. It is proposed that at a majority of these meetings students shall present papers upon subjects of their own choosing. Excursions will be made to manufacturing plants in the vicinity of the University, and arrangements for these excursions will be discussed at the next meeting.

The Branch began the year with a business meeting on October 11, when plans were discussed. Many new men have signified their intention of enrolling, and a banner year is looked for.

The *University of Wisconsin Student Branch* will hold both

social and technical meetings during the year. In the former, it will participate with other engineering clubs at the college and will also take part in the annual sophomore smoker. At the technical meetings engineering subjects will be presented and discussed, as well as topics of general engineering history.

Meetings are held the first and third Thursdays of every month.

The increase in membership of the *Brooklyn Polytechnic Student Branch* will serve as an incentive toward the increase in social and technical activities for the coming year. A unique feature of the program for the meetings is that the speakers will be members of the alumni. The graduates are employed in such varied and interesting phases of the mechanical engineering profession that an attractive list of papers is assured.

The usual trips to places of interest to the future engineer will be continued with added zest. The Program Committee is now corresponding with the executives of many of the manufactories, power plants and office buildings situated in or near New York City.

A great endeavor will be made this season to focus attention on the social side of our activities. While heretofore it has been customary after meetings to turn to general discussion, it has not been customary to have an informal dance. A canvass will be made and if opinion approves of the idea, there is no reason why such events cannot be held.

The *Penn State Chapter* opened their season with a preliminary meeting, at which the new committees were announced, followed by a social meeting at which the new faculty members were introduced and made addresses. These members are Professor E. A. Fessenden, J. W. Haney, J. O. Keller and R. C. Fielding.

The program for the year includes the following addresses by faculty members and others and discussions by student members:

Calvin W. Rice, Secretary, Am.Soc.M.E., on Work of the Student Chapters.

R. L. Sackett, Mem.Am.Soc.M.E., Dean, School of Engineering, on Revision of Steam Power Plants.

E. A. Fessenden, Mem.Am.Soc.M.E., Professor of Mechanical Engineering, on How Scientific Investigation is Attacked.

Hugo Diemer, Mem.Am.Soc.M.E., Professor of Industrial Engineering, on The Scientific Determination of Processing Standards.

J. A. Mease, Mem.Am.Soc.M.E., Associate Professor of Machine Design, on The Steel Industry, from Ore to Finished Product.

E. N. Bates, Assistant Professor of Mechanical Engineering, on Development of the Gas Engine.

J. P. Calderwood, Mem.Am.Soc.M.E., Associate Professor of Mechanical Engineering, on The Use of Kerosene in Gas Engines.

On October 13, H. L. Swift, Mem.Am.Soc.M.E., addressed the Chapter on Electric Railroad Operation.

The *University of Maine Student Branch* is anxious to make this year the best in its history. Tentative plans are under consideration for meetings to be held once a month. It is hoped that the Society will make it possible this year for the Branch to receive visits from some of its speakers.

The *Case School of Applied Science Student Branch* will hold its first meeting on October 17. Secretary Rice has very kindly consented to address this meeting, and a number of Cleveland members of the Society have accepted an invitation to be present. This generous coöperation of the Secretary and the local members of the Society will assist the Branch in attaining the proper momentum for the year.

Other meetings of the Branch will be held on November 1, December 6, January 10, February 7, March 7, April 4 and May 2. The last meeting is designated as the Annual Meeting.

The usual procedure will be to hold a dinner at six p.m. on meeting nights, the meeting to follow the dinner.

The program for these meetings includes papers on salesmanship, advertising, and also some papers on special engineering topics by Cleveland members of the Society who have kindly offered their assistance. One meeting will be given over to a discussion of technical subjects by various members of the Branch.

The local branch is now very happily situated in being able to use the new Case Club for its meetings.

Regular meetings of the *Worcester Polytechnic Student Branch* will be held on the first Friday of each month. The several professors in charge of the work of the department of mechanical engineering have been assigned one meeting each, and will assist the student officers in securing speakers and making other arrangements.

The October meeting will be devoted to Steam Engineering; November to Shop Engineering; December to Heat Treatment of Steel; January to Machine Design and Materials of Construction; February to Hydraulic Engineering, and March to Automobile Engineering. The regular time for the April meeting coming this year during the Spring recess, a Joint Meeting will be held under the auspices of the Electrical Engineering Society. In May will occur the annual meeting of the Branch for the election of officers and reports by members from the senior class on their thesis work.

The friendly rivalry between the several sub-departments in arranging for the meetings results in a series of well-balanced and most interesting lectures as each professor tries to secure the best talent possible for his special meeting.

It is expected that the meetings will be well attended judging from the way this arrangement has worked in the past.

The meetings are open to the public and special invitations are sent each month to those interested.

The newly organized Branch at the *Louisiana State University and Audubon Sugar School* plans to make a special campaign early in the season for increasing its membership.

The programs of the meetings will include several addresses by practising engineers, and a strong effort will also be made to get well-prepared papers by students. The University has lately acquired a motion picture machine, and the Branch will secure a number of films on engineering subjects. Inspection trips will be made, particularly to sugar factories and oil refineries in the vicinity of the college.

In carrying out its program for the year, the *Carnegie Institute of Technology Student Branch* will hold meetings the second Wednesday of each month. The Branch expects to obtain addresses from Elmer K. Hiles, Mem.Am.Soc.M.E., George H. Neilson, W. C. Bates, F. W. Winter, H. F. Ferguson, Frederick H. Parke and J. C. Hobbs, Mem.Am.Soc.M.E., and also some of its own alumni.

Light refreshments will be served at each meeting.

The business session and Dutch Lunch will be held in May, 1917.

The *University of Minnesota Student Branch* plans for the coming year contemplate improvements on past methods. For instance, during the past year many regular meetings were given over to addresses and talks of a general nature. All were excellent, but the students were not taking part, and it is proposed that each one shall be up and doing and therefore a greater number of reviews and discussions will form the basis for future meetings.

An open debate upon some live engineering question will furnish material for one or more meetings. It is hoped that the Branch may be able to get motion pictures of manufacturing processes and to-the-point lectures to accompany each set of films. It is proposed to keep in closer touch with the other student branches and try out a plan for the interchange of ideas and methods.

The annual "Get-together" is the best scheme yet evolved for getting up enthusiasm in the work and attracting prospective mechanical engineers to the Branch.

It is further proposed to give a dinner-dance just before the Christmas vacation in order that the Branch members and guests may have an opportunity to get better acquainted.

The first meeting of the Branch will consist of discussions of plans to govern future activities, and at that meeting there will undoubtedly be proposed further means to make the Branch of greater service to the members and to the University.

The *Bucknell University Student Branch* has decided to follow its plan of last year. About once each three months the Branch expects to have some outside engineer give an address, and other meetings will be devoted to expositions, given by seniors, of work done during the summer months. These expositions will be followed by discussions.

The general idea of the Branch is to acquaint its members with the various branches of the engineering profession, and the leading thought in all discussions will be that of instruction as to processes, methods and efficiency in system.

The *Colorado State Agricultural College Student Branch* will hold regular meetings twice every month. The programs will be arranged by the officers of the Branch and topics assigned to members for presentation. Topics are to be chosen from The Journal, from other technical papers and from practical experience. It is also the aim of the Branch to arrange for addresses by men of the engineering profession. The Branch plans to get in touch with the engineers of the under classes and keep them interested in the mechanical engineering profession. Some time during the year it is proposed to have a joint meeting with the other technical organizations.

The *Lehigh University Student Branch* will hold monthly meetings as heretofore the second Thursday of each month. At each of these meetings there will be two addresses, one given by a student-member of the Society, and the other by a graduate, prominent in engineering circles. Among the list of speakers scheduled for the coming year are Dr. J. W. Richards, of the American Electrochemical Society, whose talk will deal with the work of the newly-organized Naval Advisory Board, of which he is a member; R. E. Anderson, 1st Assistant General Superintendent of The Winchester Repeating Arms Co., who will speak on the Taylor System as it is in vogue where he is working. Then there will be an address on the Schwab Bonus System by some prominent member of the Bethlehem Steel Co. In an endeavor to bring about closer coöperation between the several engineering societies of the University, there will be a combined meeting of these societies in the near future.

The president of the *Armour Institute of Technology Student Branch* reports that it has repeatedly been brought before the attention of engineering students that engineers in general are greatly lacking in the presentation of papers or as factors in a general discussion. The absence of debating societies and declamation contests in the present day engineering colleges has led the student members of the Society at Armour Institute of Technology to adopt a different procedure in meetings for 1916-17 than has been followed in years previous. At each semi-monthly meeting, three or four members will be called upon for 5-minute talks on subjects as they themselves shall select. After each talk a general discussion on the speaker's topic will take place. During the discussion every member will be called upon for a short extemporaneous speech on one or other of the 5-minute talks.

The addresses by prominent engineers and lecturers for the year will be attended by the Civil, Chemical, Electrical, Fire Protection and Mechanical societies coöperatively.

The A.S.M.E. smoker given in honor of the mechanical engineering students of the class of '18 was very successful. A banquet to be given before the Christmas holidays is contemplated.

The Student Branch of the Society at the *University of Kentucky* will hold bi-monthly meetings throughout the college year. Technical magazines will be closely studied by all the members, each of whom will report on the contents of the particular magazine assigned to him. In this way a large number of the engineering problems that confront the technical graduate will be brought into discussion.

A smoker to which the freshmen will be invited is contemplated for the near future as an informal but effective means of arousing their interest in the work of the Mechanical Engineering department.

The officers for the Student Branch of the A.S.M.E. of *Cornell University* for the coming school year are as follows:

R. C. Carpenter, Honorable Chairman, Sibley College; W. C. Bliss, President; R. O. Compton, Vice-President; S. M. Barr, Secretary; W. W. Robertson, Treasurer.

It was decided to have as a program of meetings for the year a combination of lectures, social meetings and debates. The first lecture will be given on the subject of the Quebec bridge disaster, by Prof. H. S. Jacoby, in the first week in November. The other meetings will be arranged for later. A canvass of all the students will be made immediately to secure active members for the Branch.

The *Yale University Student Branch* is planning to have Mr. Rice speak at its first meeting to be held November 3 and have it an organization meeting open to members only. No other definite dates have been arranged as yet, but the Branch has had many good offers from some of the best men in the country on labor questions, from manufacturers wishing to send moving pictures of their business, and well-known engineers. It is its policy to have as many demonstrations as possible of recent developments in the mechanical engineering field. One 2-hour recitation period each month has been given the Branch, in which time the heads of the other engineering schools of Yale are coming in to talk. This time will also be used for debates among the members and with other Engineering Student Organizations here.

In the winter term an exhibition in the laboratory to promote interest in Mechanical Engineering will be held. All the apparatus and machines will be run by the students and the opportunity to see what is being done in the Mechanical Engineering Department will be afforded to everyone.

There seems to be an unusual amount of interest in the Branch as is shown by a large increase in membership and the Branch is looking forward to a most successful year.

The officers for 1916-1917 are Graham M. Brush of Greenwich, Conn., President, and Irving C. Shepard of New Haven, Secretary and Treasurer.

ROLL OF HONOR

Lists of those members enlisted or contemplating enlistment in the National Guard, the Regular Army, the Naval Militia, the Navy, and in other capacities in the services of the country, have been published monthly in The Journal since the August issue. Further names of such members received since the publication of the last list appear below.

CLUETT, SANFORD L., Major, Signal Corps, National Guard, New York

HANSELL, WILLIAM H., Private, Company B, Engineer Battalion, National Guard, Pennsylvania

HERSEY, MAYO DYER, Investigation of Aviation Instruments, U. S. Bureau of Standards

KRAUS, SIDNEY M., Lieutenant, U. S. N.

OTTO, HENRY S., Private, Squadron A, National Guard, New York

PERRY, FRANK B., Civilian Volunteer Training, Cruise U. S. Navy

SHAAD, GEO C., Associate-Member of Naval Consulting Board, Member of Kansas State Committee on Industrial Preparedness

STEEL, REGINALD A., Master Engineer of 1st Battalion, 22nd Regiment of Engineers, National Guard, New York

STRAHLMANN, O. E., Aeronautical Engineer, Office of Chief Signal Officer

TREAT, SIDNEY W., Sergeant, 7th Infantry, U. S. National Guard

TRUSCOTT, HAROLD S., Captain, Company I, 4th Infantry Regiment, National Guard, Hawaii

AMERICAN CHEMICAL EXPOSITION

The Chemical Exposition at the Grand Central Palace in New York City in October emphasized the surprising adaptability of American industries to exceptional conditions, as well as the equally surprising fact that it required these very exceptional conditions to give the American chemists a chance to show what they could do.

This exposition has also shown that, contrary to the impression still held by a good many people, this country is entitled to a full share of credit for certain splendid work done in industrial chemistry. While it is true that until lately Germany led the world in the development of synthetic dyes, in the field of heavy chemicals, and especially in petroleum technology, American chemists have done highly creditable, if not quite so spectacular, work. The oil-refining and cracking process and the creation of "casing-head" gasoline are essentially American achievements. The war has found American industries dependent for some staple articles of vital importance on foreign markets which for one reason or another could not continue to supply us. In a time measured by months problems were solved which would take years under any ordinary conditions.

That America led the world in the production of heavy steel materials was shown many years ago by Captain William Jones at the now historical meeting of the British Association, but until 1914 the highest grades of automobile steel used still came from Europe. Some of these were secret steels made according to carefully preserved recipes. In a surprisingly short time leading companies in this country have developed the production of these special steels so that their physical characteristics are in no wise inferior to the imported articles.

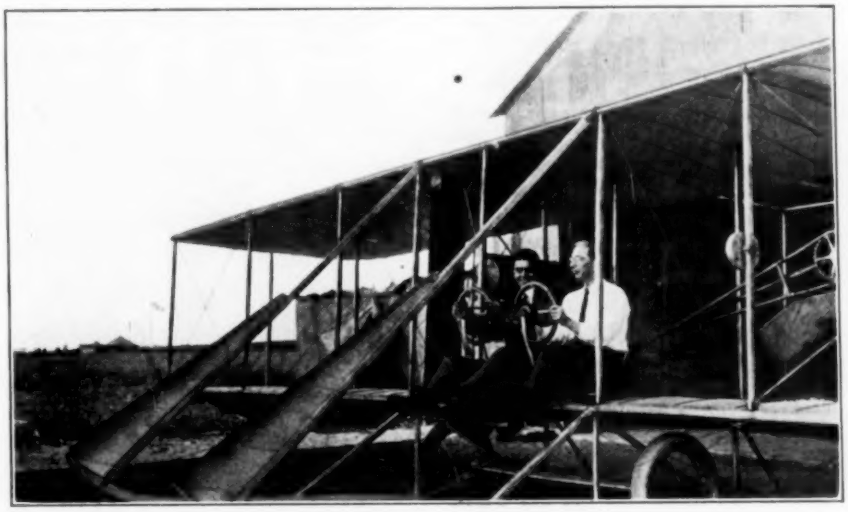
The spectacular development of the production of munitions in this country is too widely known to need more than passing mention. Less is known of the fact that, for example, this country is now leading in the production of radium and is likely to continue to do so. Even in the production of dyes, photographic chemicals and pharmaceutical products remarkable advancement has been made, especially remarkable if we consider the shortness of the time during which it was made.

A PAST-PRESIDENT'S AVIATION EXPERIENCES

A Letter from James Hartness Describing His Interesting Experiences in Aviation and Emphasizing the Importance of This New Field to Engineers

To the Editor:

My vanity or something else has suggested to me that Journal readers might be interested to know one of the uses to which ex-Presidents may be put. After my term of service I tried aviation and found it fully as preoccupying as the duties of President of the Am.Soc.M.E. I think it is one of the ways by which ex-Presidents may be kept busy.



James Hartness, Past-President Am.Soc.M.E., as Aeronaut and Pilot

Seriously, I consider the question of aeronautics one of vital importance to the members of our Society. It is distinctly an engineering problem. The aeroplane at the present stage needs the engineer more than anything else. I am looking forward to a great development in this direction within the next five years, and in view of the importance of the subject believe it should be kept prominently before our members.

One of the results of my experience in learning to fly has demonstrated the fact that it is possible for a man of my age to reach a point where he can handle a machine with reasonable safety. The Canadian Government does not take any men for training for war service who are over 23 years old. Some authorities think that good flyers cannot be made out of timber that is over 35 years of age, and, as a matter of record, I believe few men have learned after passing the fiftieth mark. I am, as you know, 55 years old, and I have gone through my course at the Wright school and passed the examination for aviator's certificate which is issued under the rules of the Federation Aeronautique Internationale, with the authority of the Aero Club of America. I have had in all over 60 flights and have been intrusted with a machine without a pilot for six flights.

I became interested in the matter of flying when taking my first flight in a Zeppelin at Leipsic during our joint meeting with the Verein deutscher Ingenieure. This was followed when the opportunity afforded by a flight in a Burgess-Dunne seaplane at Marblehead and about half a dozen flights in the Heinrich tractor at Garden City. Then I entered on a course of instruction with the Wright school which was established at Garden City last spring. The usual length of time for the regular students runs from one to two months, but my lessons were drawn out over a longer period because I spent alternating weeks at home.

I am told that the usual course of instruction in other schools begins with familiarizing the student with the working of the engine and the various controls of the aeroplane and the general behavior of the machine while on the ground. A number of runs, at first short and then longer, are taken in the machine on the ground without rising into the air. This is followed by jumps, during which the machine is allowed to rise from the ground for short distances. After that actual flights of gradually increasing duration are attempted.

The machine used was a slow-flying type known as their Type B biplane, which is practically the same as the Wright machine of eight years ago, with the wings warped to effect the banking and lateral lever control. The course was completed, however, with another machine, in which both wings were rigidly braced and flaps or ailerons were used for the lateral control.

But the instructor, Mr. Howard Rinehart, did not follow that method. He started the student first with a "joy ride." After that he allowed the student gradually to assume the control. The art of getting the machine off the ground and alighting was left to the latter part of the course. In my own experience, the order of my acquisition of the various elements of the art of flying might be summarized as follows:

I first gained the ability to keep the machine in lateral bal-

ance in flying straight away; then followed the use of rudder and warp for turning in a large circle; next the smaller circles in both right and left turns, making figure 8's, and during these flights, which vary from 2 to 10 min., I was permitted gradually to assume more and more of the control during the get-away. But the art of controlling the angle of climb and the art of landing were the last and the most difficult.

Barring unsteady air currents and machine troubles, the amateur's danger seems to lie chiefly in stalling in getting away and in flying, and in the general problem of landing.

The stalling is due to trying to climb too fast, for this retards the speed of the machine through the air and renders the control ineffective.

In steady air the experienced pilot is able to make his landing by swooping down and nicely leveling his course just to clear the ground, and let the wheels touch at the slowest speed at which the controls are effective.

The machine used is shown in the photograph. It is a slow-flying Wright biplane known as their Type B. It is practically the same as the Wright machine of eight years ago. with the wings warped to effect the banking and lateral control. The course was completed, however, with another machine, in which both wings were rigidly braced and flaps or ailerons were used for the lateral control.

In these machines, the dual control with instructor and student sitting side by side, the conditions seem ideal, for each may see what the other is doing. This not only makes it possible for the instructor to direct the student by prearranged signals, but it also leaves no doubt in the student's mind of the extent of control exercised by the instructor. In the machines in which the two sit in tandem position, the student is not always sure that the instructor has not gently changed the control.

The machines were driven with a 35-h.p. Wright engine. I have no accurate data as to the speed, but I understand it would get away from the ground at less than 30 miles an hour and could not fly over 45 miles an hour. This is a training biplane, different from the high-speed tractors which the Wright Company is building for other purposes. The slow-speed machines fly so close to a stall that they must be handled properly or they go wrong. A stall of the machine does not necessarily indicate a stall of the engine. It simply means that the aeroplane loses its speed in the air below a point at which the controls are effective. Then it is liable to side slip or do any one of the number of things that invite trouble.

The type of control used is a modification of the Wright system which brings it nearer to the Deperdussin control, called "Dep" control, but the Wright does not use the foot control rudder. For lateral balance the "Dep" control uses a wheel located about the same as an automobile steering wheel, only in normal position it is vertical instead of inclined. Turning the wheel to the right or left tips the machine in similar directions. The wheel is pivoted to the frame, on which it may be moved forward and back, and this motion controls the elevator which raises or lowers the course of the machine. The Wright rudder is a lever on this hand wheel which is similar to the throttle of an automobile.

This letter may seem very elementary, especially to the aeronautical members of the Society, but in view of the newness of the art I think we should not hesitate to set forth the subject in a way to benefit those who have not entered into it.

I am sending a photograph showing the two seats of the aeroplane occupied by the youngest and oldest members of the class. Mr. Mott from Winnipeg is the younger man. He is one of the many Canadians who have come to this school to train preparatory to entering the British aviation service.

Yours sincerely,

JAMES HARTNESS.

BIRMINGHAM SECTION INSPECTION TRIP

Our new Section at Birmingham has formed the opinion that not only is the "inspection trip" type of meeting beneficial to the members, but that it has also a great value in the stimulating of interest among the manufacturers and managers of large works and will do much toward bringing the engineering profession into public notice and recognition.

The first meeting of the Section for this season, held on September 16, was of the nature of an inspection trip through two of the local manufacturing establishments, and R. E. Brakeman, chairman, considers that the meeting was one of the best the Section has had and reports that the next

VACUUM PANS PARTIALLY ERECTED AT WORKS OF COYNE AND JOUBERT FOUNDRY CO.

trip is looked forward to with interest. In Mr. Brakeman's own words:

The members of the Section met at 1:30 p.m. at the Tutwiler Hotel, where automobiles were in waiting to carry them for the trip.

The first stop was made at the Avondale Works of the Continental Gin Company, which has two factories and its central office in Birmingham. Mr. R. S. Munger, a pioneer developer of ginning machinery, and his two sons met the members and escorted them through the plant. We first visited the experimental laboratory, where a four-gin unit was set up for our inspection. The principal features of construction and design were explained to us, the unit was put into operation, and the members were given an opportunity to see cotton ginned and baled.

From the laboratory we were taken through the factory and shown how the saws were stamped out, how the fine teeth were made and how these teeth were filed and sharpened.

The next factory visited was the plant of the Coyne & Joubert Foundry Company. This company makes a specialty of large loam castings and at present is engaged almost entirely on orders for sugar-making machinery. The illustration shown gives an idea of the large size of castings made in this shop; these vacuum pans range from 12 to 15 ft. in diameter. The general manager, Mr. Goslin, conducted our party through his shop and showed every part of the works to us.

APPLICATIONS FOR MEMBERSHIP

MEMBERS are requested to scrutinize with care the following list of candidates who have filed applications for membership in the Society. These are subdivided according to the grades for which their ages qualify them, and not with regard to professional qualifications, i.e., the ages of those under the first heading place them under either Member, Associate or Associate-Member, those in the next class under Associate-Member or Junior, and those in the third under Junior grade only. Applications for change of grading are also posted.

The Membership Committee, and in turn the Council, urge the members to assume their share of the responsibility of receiving these candidates into membership by advising the Secretary promptly of any one whose eligibility for membership is in any way questioned. All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every Member to promote. Unless objection is made to any of the candidates posted by December 10, 1916, and providing satisfactory replies have been received from the required number of references, these candidates will be balloted upon by the Council. Those elected will be notified about January 15, 1917.

NEW APPLICATIONS

FOR CONSIDERATION AS MEMBER, ASSOCIATE OR ASSOCIATE-MEMBER

AKIMOFF, N. W., Mechanical Engineer, Dynamic Balancing Machine Co., Philadelphia, Pa.

BROWN, LEWIS K., Vice-President, The Burton-Townsend Co., Beverville, Ohio

BRYAN, ALBERT H., Supervising Chemist, Arbuckle Bros., New York

CARRELL, WILLIAM A., In charge of Tractor Motors, International Harvester Co., Milwaukee, Wis.

CASHEN, HENRY C., Master Mechanic, The Bradley & Hubbard Mfg. Co., Meriden, Conn.

CHISHOLM, CHARLES R., Cristobal Shops, Panama Canal, Cristobal, C. Z.

CROCKER, ERNEST B., Mechanical Engineer, The Ashcroft Mfg. Co., Bridgeport, Conn.

FLYNN, CHARLES A., Superintendent, Park Row Building, New York

HERNON, JOSEPH L., Superintendent of Engineering, Repair Dept., Douglas Robinson, Charles S. Brown Co., New York

IMESON, CHARLES V., Resident Engineer for "The Quebradas Co.," La Quebradas, Guatemala, C. A.

JACKMAN, CHESTER C., Factory Manager, Massachusetts Saw Works, Springfield, Mass.

KENDALL, MYRON A., Chief Engineer and Superintendent, Stephens-Adamson Mfg. Co., Aurora, Ill.

LANDFEAR, GEORGE H., Works Engineer, Kathodion Bronze Works, Nyack, N. Y.

LINKER, HARRISON S., Squad Foreman, Drawing Room, Cambria Steel Co., Johnstown, Pa.

McJILTON, JOHN P., Designing and Inspecting Engineer, Locomotive Superheater Co., New York

MUELLER, HERMANN, Manager Laidlaw Sales Dept., Worthington Pump & Machinery Corp., Cincinnati, Ohio

PERRY, OLIVER N., Mechanical Engipeer, Ashcroft Mfg. Co., Bridgeport, Conn.

PUGH, ACHILLES H., President, The A. H. Pugh Printing Co., Cincinnati, Ohio

RADDANT, WALTER C., Chief Engineer, Elia Sugar Co., Elia, Province de Camguay, Cuba

RANDEL, B. F., Mechanical Engineer, Los Angeles Gas & Electric Corp., Los Angeles, Cal.

RENKIN, WILLIAM O., Chief Engineer, A. M. Byers Co., Pittsburgh, Pa.

SCHATZ, WILLIAM J., Lubrication Engineer, Platt & Washburn Co., New York

SHARPE, GEORGE H., Mechanical Engineer, New York Central Railroad, New York

SHAW, JOHN C., In charge Special Design, Keller Mechanical Engraving Co., Brooklyn, N. Y.

STEVENS, EDSON M., Consulting Engineer, Stevens & Stiles, Kansas City, Mo.

STINSON, IRVING J., Chief Draftsman, American Steel & Wire Co., New Haven, Conn.

STRENG, LEWIS S., Superintendent Electric Dept., Louisville Gas & Elec. Co., Louisville, Ky.

WAGENSEIL, EDGAR W., with Burke Furnace Co., Chicago, Ill.

WILLIUS, GUSTAV, JR., Mechanical Engineer, Robinson, Cary & Sands Co., St. Paul, Minn.

WILSON, JOSEPH H., Assistant to General Superintendent, The American Rolling Mill Co., Middletown, Ohio

FOR CONSIDERATION AS ASSOCIATE-MEMBER OR JUNIOR

BACHMEYER, WALTER G. C., formerly with Walter Kidder, Engineer and Constructor, New York

BAKER, DONALD A., Chief Tool Designer, Williams Mfg. Co., Ltd., Montreal, Canada

BARKELEW, JAMES T., Engineer and Patent Attorney, Los Angeles, Cal.

BAUMGARTNER, ARTHUR A., Draftsman, Thomas Devlin Mfg. Co., Burlington, N. J.

BAYLIS, JOHN R., Manager Water Works, Jackson, Miss.

BIGELOW, CARLE M., Efficiency Engineer, Cooley & Marvin Co., Boston, Mass.

BREWER, ALLEN F., Inspector, Appraisal Dept., Board of Public Utility Commissioners, State of New Jersey, Newark, N. J.

CHUCAN, JOHN, Designer, Tractor Works, International Harvester Corp., Chicago, Ill.

ELSTON, SIDNEY B., Chief Draftsman, Climax Mfg. Co., Corry, Pa.

FINN, STEPHEN M., Assistant Engineer, American Engineering Co., Philadelphia, Pa.

HEEKIN, DANIEL M., Superintendent, The Heekin Can Co., Cincinnati, Ohio

HUXFORD, GEORGE T., Designing Engineer, Builders Iron Foundry, Providence, R. I.

JOHNSON, ASHMORE C., With Coatesville Boiler Works, Philadelphia, Pa.

KEENAN, WALTER M., Assistant to Mechanical Engineer, New York Edison Co., New York

KOSSIF, NISSIM, Engineer of Tests, Schaum & Uhlinger, Inc., Philadelphia, Pa.

MARSH, FRANCIS G., Lieut. (Jr. Grade), U. S. Navy, Post Graduate Course, Columbia University, New York

SHANLEY, FREDERICK R., Efficiency Engineer, Staff of L. V. Estes, Inc., Chicago, Ill.

WOLFF, WILLIAM S., Graduate, University of Minnesota, 1916, St. Paul, Minn.

FOR CONSIDERATION AS JUNIOR

AAGAARD, ARTHUR H., Instructor, Steam & Gas Engineer, College of Mechanics and Engineering, University of Wisconsin, Madison, Wis.

AMES, JOHN H., Engineering Division, The Lunkenheimer Co., Cincinnati, Ohio

BARKER, GEORGE S., Draftsman, Niles-Bement-Pond Co., New York

DIETRICH, FRED C., Assistant to Chief Engineer, Standard American Dredging Co., Oakland, Cal.

EBERHARDT, JOHN D., Draftsman, Plan Dept., Associated Factory Mutual Ins. Cos., Boston, Mass.

EHRHARDT, JOHN J., Assistant Engineer, American Sugar Refining Co., Brooklyn, N. Y.

HENLEY, ERL K., 2nd Assistant Engineer, Naval Auxiliary Service, U. S. S. "Nereus," New York

HOBART, JAMES C., JR., The Le Blond Machine Tool Co., Cincinnati, Ohio

HORN, NORMAN E., On staff of Walter B. Snow & Staff, Boston, Mass.

HULBURT, WYNNE D., Rate Setter, German-American Button Co., Rochester, N. Y.

KENT, ROBERT W., Industrial Engineer, Cooley & Marvin Co., Boston, Mass.

KRAMPE, HUGO J., With Armstrong Cork & Insulation Co. of Pittsburgh, Pa., Cincinnati, Ohio

PROZAN, MOSES, Draftsman, Brunswick Refrigerating Co., New Brunswick, N. J.

SHETLAND, WALTER A., Industrial Engineer, Remington Arms & Ammunition Co., Bridgeport, Conn.

WOOD, CHARLES E., In charge Erection New Foundry, Lunkenheimer Co., Cincinnati, Ohio

WOODCOCK, WILLIAM E., Special Apprentice, New York Central R. R., West Albany, N. Y.

WOODWARD, HIRAM W., with Alex. Brown & Sons, Baltimore, Md.

APPLICATIONS FOR CHANGE OF GRADING

PROMOTION FROM ASSOCIATE-MEMBER

LUNDGREN, FREDERICK G., Master Mechanic & Efficiency Engineer, American Car & Fdy. Co., Milton, Pa.

PROMOTION FROM JUNIOR

BAILLIERE, MARION V., Mechanical Engineer, New York Central R. R. Co., Cleveland, Ohio

DAUCHY, SAMUEL E., General Superintendent, Worcester Mfg. Co., Worcester, Mass.

GILLAN, HOWARD A., Assistant Engineer with Consulting Engineer, Union Pacific System, New York

KOCH, WILLIAM H., JR., Consulting Engineer, Staff with Meyer, Morrison & Co., Inc., New York

RICHARDSON, GEORGE P., Assistant Engineer, Isbell-Porter Co., Newark, N. J.

RUPPEL, RICHARD, Chief Engineer, J. Byers Holbrook (Griggs & Holbrook), Consulting Engineer, New York

UNDERWOOD, CHARLES N., Head Time Study Department, Remington Typewriter Works, Ilion, N. Y.

SUMMARY

New Applications	65
Applications for change of grading:	
Promotion from Associate-Member	1
Promotion from Junior	7
Total	73

SUMMARY SHOWING AVERAGE AGE AND POSITIONS OF APPLICANTS ON BALLOT CLOSING SEPTEMBER 26, 1916

Average Age of Applicants:

Members	44
Associates	40
Associate-Members	34
Juniors	24

Classifications of Positions Held:

Cadet Engineer	1
Chemical Engineers	2
Chemical Engineer (Asst.)	1
Chief Engineers	15
Chief Engineer (Asst.)	1
Commercial Engineer	1
Construction Engineers	5
Construction Engineer (Asst.)	1
Consulting Engineers	7
Cons. Marine Engineer	1
Designers	10
Draftsmen	15
Draftsmen (Chief)	4
Draftsmen (Asst. Chief)	3
Efficiency Engineers	2
Electrical Engineers	2
Experimental Engineer	1
Engrg. Examiner	1
Executives (Pres., Vice-Pres., Treas., Secys., Mgrs.)	34
Head Educational Dept	1
Industrial Engineers	2
Inspectors	6
Inspector (Asst.)	1
Laboratory Asst	1
Mechanical Engineers	28
Mechanical Engineers (Asst.)	14
Operating Engineer	1
Production Engineer	1
Professors (Asst.)	4
Sales Engineers	8
Sales Engineer (Asst.)	1
Students	9
Superintendents	15
Superintendents (Asst.)	7
Safety Engineers	2
Steam Engineers	4
Supervising Engineers	4
Service Engineer	1
Spcl. Exper. Engineer	1
Utility Engineer	1
Works Manager	1
Works Manager (Asst.)	1
Ballistic Engineer (Asst.)	1
Advisory Engineer	1
Master Mechanic	1
Manufacturer	1
Junior Mechanical Engineer	1
Miscellaneous	18
Unemployed	4

GEOGRAPHICAL LIST

(Applications for promotion will be indicated by the initials of the grade)

California
Los Angeles—Barkelew, J. T.
Randel, B. F.
Oakland—Dietrich, F. C.

Canal Zone
Cristobal—Chisholm, C. R.

Canada
Montreal—Baker, D. A.

Central America
Las Quebradas—Imeson, C. V.

Connecticut
Bridgeport—Crocker, E. B.
Perry, O. N.
Shetland, W. A.
Meriden—Cashen, H. C.
New Haven—Stinson, I. J.

Cuba
Elia—Raddant, W. C.

Illinois
Aurora—Kendall, M. A.
Chicago—Chucan, J.
Shanley, F. R.
Wagenseil, E. W.

Kentucky
Louisville—Streng, L. S.

Maryland
Baltimore—Woodward, H. W.

Massachusetts
Boston—Bigelow, C. M.
Eberhardt, J. D.
Horn, N. E.
Kent, R. W.
Springfield—Jackman, C. C.
Worcester—Dauchy, S. E. (J)

Minnesota
St. Paul—Willius, G. Jr.
Wolff, W. S.

Mississippi
Jackson—Baylis, J. R.

Missouri
Kansas City—Stevens, E. M.

New Jersey
Burlington—Baumgartner, A. A.
New Brunswick—Prozan, M.
Newark—Brewer, A. F.
Richardson, G. P.

New York
Brooklyn—Ehrhardt, J. J.
Shaw, J. C.
Ilion—Underwood, C. N. (J)
New York—Bachmeyer, W. G. C.
Barker, G. S.
Bryan, A. H.
Flynn, C. A.
Gillan, H. A. (J)
Henley, E. K.
Hernon, J. L.
Keenan, W. M.
Koch, W. H. Jr. (J)
McJilton, J. P.
Marsh, F. G.
Ruppel, R. (J)
Schatz, W. J.
Sharpe, G. H.
Nyack—Landfear, G. H.
Rochester—Hulburt, W. D.
W. Albany—Woodcock, W. E.

Ohio
Beverville—Brown, L. K.
Cincinnati—Ames, J. H.
Heekin, D. M.
Hobart, J. C., Jr.
Krampe, H. J.
Mueller, H.
Pugh, A. H.
Wood, C. E.
Cleveland—Bailliere, M. V. (J)
Middletown—Wilson, J. H.

Pennsylvania
Corry—Elston, S. B.
Johnstown—Linker, H. S.
Milton—Lundgren, F. G. (A. M.)
Philadelphia—Akimoff, N. W.
Finn, S. M.
Johnson, A. C.
Kossif, N.
Pittsburgh—Renkin, W. O.

Rhode Island
Providence—Huxford, G. T.

Wisconsin
Madison—Aagaard, A. H.
Milwaukee—Carrell, W. A.

PERSONALS

In these columns are inserted items concerning members of the Society and their professional activities. Members are always interested in the doings of their fellow-members, and the Society welcomes notes from members and concerning members for insertion in this section. All communications of personal notes should be addressed to the Secretary and items should be received by the 18th of the month in order to appear in the succeeding issue of The Journal.

CHANGES OF POSITION

J. S. Kerins, formerly draftsman with the New York Edison Company, New York, has become affiliated with The Dayton Power and Light Company, Dayton, O.

E. W. Kerr, professor of mechanical engineering at the Louisiana State University, Baton Rouge, La., has become identified with the Cuba Cane Sugar Corporation, Havana, Cuba.

Thomas Richardson has entered the employ of Franco-Swiss Dyes, Inc., New York. He was formerly connected with W. S. Barstow and Company of New York, in the capacity of chief draftsman.

R. W. Rogers, formerly in the employ of the Erie Railroad Company, New York, has accepted the position of chief engineer of The Superno Company, New York.

J. H. Tuvin, formerly identified with the Scientific Materials Company, Pittsburgh, Pa., has become manager of The Tuvin Company, sales engineers of the same city.

John H. Wynne, formerly identified with the Montreal Locomotive Works, Ltd., Montreal, Que., Canada, in the capacity of manager, has become associated with the American Locomotive Company, New York.

Herbert C. Hunter has resigned his position with the Otis Elevator Company, Harrison, N. J., as shop engineer of escalators, to accept the position of manager of the printing and engraving business of Walter Hunter.

Allen V. Moyer has resigned his position as mechanical engineer with The Geo. T. Ladd Company, Pittsburgh, Pa., to assume the duties of chief draftsman and assistant chief engineer of Struthers-Wells Company, Warren, Pa.

Frank A. Burr has resigned from his position as professor in power plant economics and design at Pennsylvania State College, to assume the responsibilities of director of a school of automobile engineering in Brooklyn, N. Y.

Robert W. Morse has resigned as assistant examiner in the United States Patent Office, Washington, D. C., and has accepted a position as patent attorney with the firm of Foster, Freeman, Watson and Coit, Washington, D. C.

W. L. Bean, formerly mechanical engineer with the Oxweld Railroad Service Company, Chicago, Ill., has accepted the position of expense and method analyst with the New York, New Haven and Hartford Railroad Company, Boston, Mass.

H. S. Dickerson, until recently assistant professor of mechanical engineering at Purdue University, Lafayette, Ind., has been appointed professor of mechanical engineering at the School of Mines and Metallurgy of the University of Missouri, Rolla, Mo.

Harry A. Atwater has assumed the position of fuel engineer with the Central Coal and Coke Company, Kansas City, Mo. He was until recently in the employ of the Union Stock Yard and Transit Company, Chicago, Ill., in the capacity of mechanical engineer.

Alex. Vallance has accepted the position of assistant professor of experimental engineering at the Georgia School of Technology, Atlanta, Ga. He was until recently instructor of theoretical and applied mechanics at the University of Illinois, Urbana, Ill.

Will H. Baltzell, formerly with the Crucible Steel Company, Aetna Explosives Company and lately with the Mackintosh, Hemphill Company, Pittsburgh, Pa., has been appointed chief engineer of the Canadian Steel Corporation, Ltd., at Ojibway, Ontario, Canada.

Joseph Esherick has resigned as manager of the valve and specialty department of the Yarnall-Waring Company of Philadelphia, Pa., to become the Philadelphia representative of The D. Connelly Boiler Company, National Steam Pump Company and the Foxboro Company.

Claude M. Barron, who for the past five years has been studying and cultivating the Australasian market for railway supplies, machine tools and raw materials, has assumed the duties of consulting and purchasing engineer with Charles M. Terry, Inc., of Sydney, Australia, with offices in New York. Mr. Barron was, until recently, associated with R. W. Cameron and Company, New York, in the capacity of consulting engineer.

ANNOUNCEMENTS

Morris Kind has become associated with the Hercules Cement Corporation of Philadelphia, Pa.

Crosby Field-Frank announces that in accordance with a recent court decision, his legal name is Crosby Field.

A. W. Foote, president of the Foote-Burt Company, Cleveland, O., builders of drilling machinery, has been elected president of the H. A. Lozier Company, automobile builders of Cleveland, O.

Ross Anderson, manager of production of the Poole Engineering and Machine Company, Baltimore, Md., has assumed general management of the shops and has been given the title of works manager.

Robert E. Hall, vice-president of the Goulds Manufacturing Company, located formerly at Seneca Falls, N. Y., is now in charge of the Chicago office and Northwestern territory, with offices at 12 S. Clinton St., Chicago, Ill.

Robert R. McKechnie, who has acted for many years as mechanical engineer and assistant to the general manager of The Variety Iron and Steel Works Company, Cleveland, O., has resigned his services with that company.

Cary T. Hutchinson has been selected as the executive secretary of the Engineering Foundation to represent the engineering professions in the organization of the National Research Council proposed by the National Academy of Sciences.

George S. Hessenbruch has left the employ of the Union Electric Light and Power Company and the St. Louis County Gas Company, St. Louis, Mo., and has opened offices in the same city for the practice of gas engineering, with special attention to the by-product end.

Guy L. Bayley, who was chief of the mechanical and electrical departments of the Panama-Pacific International Exposition, has opened an office as consulting engineer in the First National Bank Building, San Francisco, Cal. Mr. Bayley is at present engaged in building an hydroelectric plant for the Department of the Interior in the Yosemite Valley on the Merced river.

W. P. Barba, vice-president of the Midvale Steel Company, Philadelphia, Pa., has severed a many years' connection with that company, during which he has occupied many positions of responsibility. He plans to spend some time in travel and later will engage in special work for which his long experience has fitted him, such as the manufacture of ordnance, guns, armor plate and high grade shell products.

Carl L. Svensen opened an evening school of drafting, on October 3, to be known as the Ohio Technical Drawing School, in Columbus, O. The purpose of the school is to furnish an opportunity for draftsmen, machinists, pattern makers, molders and others engaged in mechanical lines to study drawing as a means to increasing their earning power. The addition of courses in mechanism, mechanics and strength of materials and machine design is planned for the near future.

FORD W. HARRIS of Los Angeles, Cal., who has been Acting Secretary of the Los Angeles Section of this Society since its inception, was on October 5, 1916, admitted to practice law before the courts of the State of California. Mr. Harris is, therefore, in addition to being a member of this Society and a Fellow of the American Institute of Electrical Engineers, an attorney-at-law. Mr. Harris' practice is, however, limited to patent causes, which generally involve in a large measure engineering questions.

APPOINTMENTS

HAZEN G. TYLER has been appointed instructor in mechanical engineering at the Rensselaer Polytechnic Institute, Troy, N. Y.

CHARLES M. REED has been appointed instructor in marine engineering at the United States Naval Academy, Annapolis, Md.

WALTER MACGREGOR has been appointed general manager of Plant No. 4 of the Timken Detroit Axle Company, located in Canton, O.

S. R. WILLOCK, who has been assistant general manager of sales of The William Tod Company, Youngstown, O., since June, 1915, has been appointed general manager of sales, vice R. D. Day.

AUTHORS OF PAPERS, ETC.

WILLIAM KNIGHT has contributed an article on The Mechanical Design of Turbo-Generators to the October 17 issue of *Power*.

JOHN YOUNGER has contributed a brief article on Inspecting High-Grade Gears to the October 5 issue of the *American Machinist*.

W. E. MOORE has contributed an article on One-Man, Light-Weight Electric Railway Cars, to the October number of *The Electric Journal*.

W. H. TIMBIE is co-author with H. H. Higbie of a book, recently issued, on Alternating Current Electricity and its Applications to Industry

C. F. HIRSHFELD and T. C. ULBRICHT are joint authors of a book on Steam Power. This is one of the John Wiley and Sons' technical series of books for vocational schools.

WALTON CLARK, president of The Franklin Institute, is the author of A Century of Light, graduating address of the Institute's school, in the October *Journal of The Franklin Institute*.

JOHN E. ERICSON, city engineer of Chicago, was among the speakers at the October 6 "membership booster dinner" of the American Association of Engineers, held at the City Club, Chicago, Ill.

JOSEPH A. STEINMETZ, president of the Aero Club of Pennsylvania, presented a paper on Aerial Warfare and Some Devices Terrestrial and Submarine at the October 26 meeting of the Engineers' Club of Trenton.

FRANK B. GILBRETH, expert on management and time-study work gave an illustrated lecture on Motion Study—The Science of Obtaining Least Waste, at the October 20 meeting of the Detroit Engineering Society.

WILLIAM C. L. EGLIN presented a paper entitled Power Company's Problem in the Electric Supply for Large Single-Phase Loads at the October 13 meeting of the American Institute of Electrical Engineers held in Philadelphia, Pa.

G. LAURENCE KNIGHT presented a paper at the October 12 meeting of the Brooklyn Engineers' Club on The Construction of the Foundations for Two Large Turbo Generator Sets and for a Building under Similar and Difficult Sub Surface Conditions.

MORRIS L. COOKE, acting director of the Utilities Bureau, Philadelphia, Pa., delivered an address before the City Club of Chicago on October 10, on The City and Its Public Utilities, in which he showed the need for the bureau and its work and made a plea for its support.

EDWIN D. DREYFUS is the author of Graphic Analyses of Managerial Problems which appears in the October 7 number of *Electrical World*. The author cites instances when curves and diagrams are of great practical value in facilitating the solution and understanding of the problems of investment, revenue and expense.

NECROLOGY

HENRY FISLER RUGAN

Henry Fisler Rugan was born in Philadelphia, July 7, 1857, and died in New Orleans, September 3, 1916.

In 1864, his parents removed to Terre Haute, Indiana, where he received his education in the public schools. Later he attended Smithson College, Logansport, Indiana, where he completed his studies. He left college to become an employee of the Terre Haute and Indianapolis Railroad in Terre Haute as an apprentice-machinist, remaining with the company until 1880, in the meantime advancing to the position of foreman of one of the erecting gangs.

After two years, spent in various parts of the country working for several railroads, he returned to Terre Haute to accept a position of instructor in the Rose Polytechnic Institute. He remained with the Institute for nearly three years, leaving it to accept the position of foreman of the railroad shops of the Texas and Pacific Railroad at Big Springs, Texas. He continued with this road for five years, advancing to a position where he had charge of a division and was located in Longview and Marshall, Texas, and in Gouldsboro, Louisiana.

Leaving railroad work, he became identified with the sugar industry as chief engineer and superintendent on several large plantations of Louisiana.

In 1895, Professor Rugan accepted the position of Instructor in Mechanic Arts at Tulane University of Louisiana, in New Orleans. Here he spent the last twenty-one years of his life. He was soon advanced to the grade of Assistant-Professor, later to that of Associate-Professor and finally to that of Professor of Mechanic Arts.

He spent the year 1898-9 in Europe, most of the time at Manchester University, where he, in collaboration with Professor Carpenter of that institution, conducted extensive research work upon The Growth of Cast Irons After Repeated Heatings. The results of the work were published in the Journal of the Iron and Steel Institute, 1909. A further paper in the same Journal in 1912 was devoted to details of this work. Professor Rugan was also a contributor to the discussion of similar problems in this Society.

Mr. Rugan was devoted to the Masonic order, and received many honors from that organization.

He became a member of the Society in 1900.

ROBERT CAIRD

Robert Caird, a managing director of the old family shipbuilding and engineering company of Caird & Co., Greenock, Scotland, was born on May 22, 1852. He was educated at the Grange School, Sunderland, at the Greenock Academy, and at Glasgow University. He entered his father's works as an apprentice-engineer, continuing at this time for eleven years in the business. The years of 1881-2 he spent with the Maritime Construction Co., of Havre, and in the two following years was engineer-in-charge of construction for the Pullman Co. of Chicago. In 1888 he returned to his father's business and became one of the managing directors, taking special charge of the engineering department.

Dr. Caird was a member of the Royal Society of Edinburgh, the Institute of Metals, the Philosophical Society of Glasgow and the Philosophical Society of Greenock, and became a member of the Institution of Civil Engineers in 1900. From 1899-1901 he was president of the Institution of Engineers and Shipbuilders in Scotland.

In 1900 Glasgow University conferred upon him the honorary degree of Doctor of Laws. This was a well-merited distinction, and in bestowing it upon him the Faculty of Law gave the following reason: "His eminence as a shipbuilder has already won for him the gold medal of the Institution of Engineers and Shipbuilders in Scotland and the presidentship of that important body. The University which possesses the only British Chair of Naval Architecture may well associate herself with the Royal Society of Edinburgh in marking her appreciation of Mr. Caird's valuable contributions to this branch of applied science. We cannot keep out of view the interest which Mr. Caird has displayed in the present movement for the improvement and extension of the scientific side of the University. Mr. Caird is not merely a practical man. Following the early traditions of Scots students, Mr. Caird completed on the Continent the education he began here. In the course of several years' residence abroad he acquired an intimate and extensive acquaintance with the language and literature of France, Germany, and Italy, and he was also privileged to carry on important investigations in the domain of history and art under the direction of Mr. Ruskin. His labors in this department were recognized in 1895, when he was created a Knight of the Crown of Italy. His papers, lectures and addresses on the subject in which he is interested display not merely solid erudition, but marked literary charm."

Dr. Caird was a close student of the work of James Watt, and in 1910 delivered the Watt Anniversary Lecture before the Greenock Philosophical Society. This lecture was a characteristically scholarly memoir of Watt's contributions to the advancement of engineering. Dr. Caird was much interested in technical education, and was the author of several monographs on this subject, including The Study of Science in Relation to Education and Technical Education.

He was an active supporter of institutions in the city of Greenock. He was prominent in the founding of the James Watt Memorial School, and took the part of a captain of industry in connection with a number of local business and philanthropic institutions.

He was elected to membership in the Society in 1884. He died at his home at Greenock on December 1, 1915.

ELMER NEILL STACY

Elmer Neill Stacy was born on December 11, 1876, in Minneapolis, Minn. He received his early education at the District School and the Central High School, Minneapolis, and was graduated from the College of Engineering, University of Minnesota, in 1907. Before entering college he spent about three years in the drafting department of the Plano Manufacturing Company at West Pullman, Ill. After graduation he was employed by the Minneapolis Threshing Machine Company as draftsman and designer, and did considerable work on the testing floor. About June, 1908, he associated himself with the Decarie Incinerator Company as assistant to the general manager, and in March, 1909, he became general manager of the company, directing the design and construction of refuse disposal plants.

In April, 1914, the Stacy Bates Company was organized with Mr. Stacy as president, and arranged for the exclusive sale of the Decarie Incinerator Company's plants. He joined this company and performed the same work as with the Decarie Company.

Mr. Stacy was a member of the Sigma Xi and the Tau Beta Pi Fraternities. He became a member of the Society in 1911. He died on September 9, 1916.

ROBERT COCHRAN MCKINNEY

Col. Robert Cochran McKinney was born at Troy, N. Y., on January 20, 1852, and died on October 3, 1916. His parents moved in 1861 to Cincinnati, where he attended the public schools and Woodward High School until 18 years of age. In 1872 he entered Cornell University and took a partial course in mechanical engineering. Following this he was employed at Hamilton in the drafting room and office of a company manufacturing steam pumping machinery.

In 1877, Mr. McKinney became associated with the Niles Tool Works. Within two years he was elected secretary of the company and a little later treasurer and general manager. Under his skillful management the company grew until the business was recognized and capitalized at $2,000,000. Shortly after this, when it was necessary to secure additional property, the plant and the business of the Cope and Maxwell Manufacturing Company whose products were steam pumps was bought by the Niles Tool Works Company; later the machinery and business of the Cope and Maxwell Company was sold to another corporation and became a part of the International Steam Pump Company.

In 1898 the Niles Tool Works Company purchased control of the Pond Machine Tool Company of Plainfield, N. J., the purchase being supplemented by options on the works of Bement, Niles & Company of Philadelphia, Pa., as well as the Philadelphia Engineering Works. The company thus created is known widely as Niles-Bement-Pond Company, of which Colonel McKinney was president.

Other purchases have been made by this company including the Pratt & Whitney Company of Hartford, the Bertram Company of Canada and the Ridgway Machine Company of Ridgway, Pa.

Colonel McKinney was a member of the Union League Club, Sotos, Engineers' and Cornell Clubs of New York, the Hartford Club of Hartford, and the Queen City Club of Cincinnati, and was president of the Machinery Club of New York. He became a member of the Society in 1890.

FRANKLIN MCMILLAN STANTON

Franklin McMillan Stanton was born in New York City on May 23, 1865, and died on September 12, 1916.

Following a course of public school instruction, he entered Columbia University, graduating from the School of Mines in 1887. He immediately took up his profession, working as a surveyor and assayer for about two years, when he decided to embark in the mining field on his own account. The undertaking proved successful and led to his long connection with the Superior companies.

After a few years he was offered a position with the Atlantic Mining Company, which he accepted, soon advancing to the post of superintendent. He served in that capacity for twenty-three years, improving mining methods and creating what was considered one of the best organizations in the mining field.

Because of failing health, Mr. Stanton retired in 1910, visited most of the European countries and availed himself of the opportunity to study the mines of the Continent.

In 1914 he became treasurer and director of the Mohawk

Mining Company, the Wolverine Copper Mining Company, which controls some of the best territory in America's principal copper district and the Michigan Copper Mining Company. He was also treasurer of the White Pine Extension Copper Company which has recently been organized.

In addition to his activities in the mining field, Mr. Stanton was identified with several other enterprises. He was president and a director of the Ft. Mountain Talc Company, which operates a mine in northern Georgia, where talc abounds, and was also a director of the First National Bank, Houghton, Mich., the Ohio and Kentucky Railroad, which penetrates the coal region of those states, the Copper Range Co., etc.

A large number of professional, social and patriotic organizations included Mr. Stanton in their membership. He was a member of the American Society of Civil Engineers, American Chemical Society, American Forestry Association, American Institute of Mining Engineers, American Revolver Association, American Mining Congress, Life Membership; American Society for Prevention of Cruelty to Animals, American Museum of Natural History, Burns Society, American Automobile Association, Psi Upsilon Fraternity, Lambda Chapter; Washington Continental Guards, The Navy League of the United States, Life Membership; Seventh Infantry N. G. N. Y., Regimental Mess, Life Membership; Seventh Regiment Veteran and Active League, Society of Upper Eighties of Columbia University, St. George's Society, Sons of the Revolution, Society of Colonial Wars, United Engineering Society, Columbia College Alumni, Houghton Life Infantry, Horticultural Society of New York, Lake Superior Mining Institute, Michigan State Rifle Association, Life Membership; National Security League, Life Membership; National Rifle Association and the Columbia University Athletic Association. He was also a member of a number of social clubs. He became a member of the Society in 1892.

SOCIETY MEETINGS

Meetings of the Society are now being held regularly at established Sections at Atlanta, Birmingham, Boston, Buffalo, Chicago, Cincinnati, Detroit, Indianapolis, Los Angeles, St. Paul and Minneapolis (Minnesota Section), New Haven, New Orleans, New York, Philadelphia, St. Louis, San Francisco and Worcester; also the Providence Engineering Society, which is affiliated with our Society, holds regular meetings. Sections are in prospect at Baltimore, Erie, Kansas City, Meriden and Rochester.

ORGANIZING A SECTION

The Committee on Sections is anxious to have the number of Sections extended to all centers where the membership is sufficiently large to warrant the holding of regular meetings. In the places where Sections are now established, those participating in the work find it interesting and beneficial, and much good has resulted to the individual members as well as to the Society.

A Section of the Society may and preferably should coöperate with and help build up the local engineering organizations by the holding of joint meetings, and invite all members of such organizations and all engineers generally to its meetings. This phase of Section work has been specially well developed at several large cities represented on our Section list.

The Society is willing to assist groups of members in the organizing and developing of Sections, both by appropriation to cover fixed expenses and by advice regarding lines of activity.

It is suggested that in places in which the membership in the Society is over twenty some member or members take the initiative in organizing a meeting to discuss the advisability of petitioning the Council for the formation of a Section.

STUDENT BRANCHES

The Society has now affiliated with it forty Student Branches, which are independent organizations of students in the following educational institutions:

Armour Institute of Technology............Chicago, Ill.
Bucknell College ....Lewisburg, Pa.
Carnegie Institute of Technology........Pittsburgh, Pa
Case School of Applied Science.........Cleveland, Ohio
Colorado State Agricultural College...Fort Collins, Colo.
Columbia University ....New York
Cornell University ....Ithaca, N. Y.
Georgia School of Technology............Atlanta, Ga.
Kansas State Agriculture College......Manhattan, Kan.
Lehigh University ....So. Bethlehem, Pa.
Leland Stanford Jr. University, Stanford University, Cal.
Louisiana State University...........Baton Rouge, La.
Massachusetts Institute of Technology, Cambridge, Mass.
New York University................New York, N. Y.
Ohio State University.................Columbus, Ohio
Pennsylvania State College..........State College, Pa.
Polytechnic Institute of Brooklyn.......Brooklyn, N. Y.
Purdue University ....Lafayette, Ind.
Rensselaer Polytechnic Institute..........Troy, N. Y.
State University of Iowa....................Iowa, Ia.
State University of Kentucky..........Lexington, Ky.
Stevens Institute of Technology.........Hoboken, N. J.
Syracuse University ....Syracuse, N. Y.
Throop College of Technology..........Pasadena, Cal.
University of Arkansas..............Fayetteville, Ark.
University of California................Berkeley, Cal.
University of Cincinnati..............Cincinnati, Ohio
University of Colorado..................Boulder, Colo.
University of Illinois......................Urbana, Ill.
University of Kansas.................Lawrence, Kan.
University of Maine........................Orono Me.
University of Michigan...............Ann Arbor, Mich.
University of Minnesota...........Minneapolis, Minn.
University of Missouri..................Columbia, Mo.
University of Nebraska..................Lincoln, Neb.
University of Wisconsin.................Madison, Wis.
Virginia Polytechnic Institute..........Blacksburg, Va.
Washington University ....St. Louis, Mo.
Worcester Polytechnic Institute........Worcester, Mass.
Yale University ....New Haven, Conn.

Johns Hopkins University has recently held an organization meeting with the idea of establishing a Student Branch.

Institutions in which the entrance requirements are equivalent to those established by the Carnegie Foundation are eligible for Student Branches. Bodies of students in the engineering departments of such colleges are invited to apply to the Secretary of the Society for information regarding the form of petition to the Council for a Student Branch.

It is of the highest importance in the development of the monthly meetings of the Society, both of the Sections and of the Student Branches, that comprehensive reports of these meetings be published in The Journal regularly. Secretaries of the Sections and Student Branches are urged to make

every effort to get the complete reports of their meetings to the office of the Society as quickly as possible after the meetings are held, and also where possible, copies of the papers presented should be sent in; if desired, the copy of the paper will be returned after examination. Reports of meetings must be received before the 18th of the month in order to appear in the next issue of The Journal.

MILWAUKEE, SEPTEMBER 13

The first meeting of the Milwaukee Section for the season 1916-1917 was very encouraging. There were 183 members and guests present. L. J. D. Healey, chief chemist of the Federal Rubber Company, gave an interesting talk on Growing and Gathering of Rubber Latex.

Following the talk, Mr. Hutchens, Chairman of the Section, arranged for those present to be conducted through the plant of the Federal Rubber Company, where they were shown how automobile tires and mechanical rubber goods are made. The party was then shown some very interesting moving pictures of the rubber industry. A surprise supper, served in the dining room of the Federal Rubber Company, concluded the meeting.

FRED H. DORNER,
Section Secretary.

MINNESOTA, SEPTEMBER 14

The first meeting of the Minnesota Section for the season 1916-1917 was held in the main engineering building of the University of Minnesota, at Minneapolis. Prof. J. V. Martenis, chairman of the Section, presided and outlined in detail his plans for the work of the Section for the coming season. Working committees for the ensuing year were also appointed.

Following the regular business meeting, a very interesting talk was given by C. W. Obert, Mem.Am.Soc.M.E., and Secretary of the A.S.M.E. Boiler Code Committee, Secretary of the American Society of Heating and Ventilating Engineers on the plan of working of the Society and the method of presenting and publishing papers.

FRED A. OTTO,
Section Correspondent.

BIRMINGHAM, SEPTEMBER 16

The first meeting of the Birmingham Section for the season 1916-17 was held on September 16, and was in the nature of an inspection trip through the Avondale Works of the Continental Gin Company and the plant of the Coyne and Joubert Foundry Company, which makes a specialty of large loam castings and at present is engaged almost entirely on orders for sugar-making machinery. A more detailed description of the trip appears elsewhere in this issue.

PAUL WRIGHT,
Section Secretary.

CINCINNATI, SEPTEMBER 21

A joint meeting of the Cincinnati Section of the Society and the Engineers' Club was held on September 21, at which C. F. Kettering, Mem.Am.Soc.M.E., assistant general manager of the Dayton Engineering Laboratories Company, spoke on Some Present and Future Carburetion Problems. Mr. Kettering mentioned the enormous increase from year to year in power obtained from liquid fuels, and stated that the horsepower for motor car engines at the present time runs into many millions. He pointed to the increasing density of the liquid fuels that are used in internal combustion engines, particularly in motor car engines. Many of the difficulties of carburetion and of ignition that have occurred in the past and are occurring now are due, he stated, to this increasing density, which is necessitated by the enormously increasing use of liquid fuels. Manufacturers who are getting out a certain model of car will be working with a fuel which is representative of the kind that is available in the market at the time, but by the time the model is manufactured, the character of the fuel will have changed so much as to cause ignition and carburetion difficulties. Mr. Kettering gave specific instances of this and mentioned that such difficulties are liable to increase, rather than diminish.

Mr. Kettering traced the progress of the mixture, in an internal combustion engine, from the carburetor through the manifold into the cylinder, and throughout the operations of compression and ignition. He showed the effect of increasing density upon carburetion, and in rendering the fuel liable to be precipitated by centrifugal action at bends in the manifolds. The precipitation of the heavier fuel upon the walls of the cylinder, where it would dissolve the lubricating fuel and run down past the piston, and the liability, under some conditions, of the water of combustion to pass by the piston, accounted, he stated, for some remarkable cases of water in the crank case, and also for the apparent increase of the quantity of lubricating oil in the crank case.

The speaker dwelt upon the double explosion obtained with some engines using kerosene and other low-density fuels, and stated that the first of these explosions occurs at lower temperatures than would ignite lighter liquids. This apparent paradox he explained by the catalytic action of carbon just released from its bond in a compound.

He predicted a great future in this country for the Diesel engine, because its action is very positive and many carburetion and ignition difficulties inherent in other types disappear in this. He believed that improvements in workmanship and materials used for Diesel engines would be necessary before great success would be obtained.

He gave a short account of a recent visit to Fremont, where many tractors of all sizes had been tested. He analyzed some of the troubles encountered with these tractors.

He concluded by stating that the many attempts being made displace the horse with power-operated agricultural tools were extremely significant, and would undoubtedly meet with success. We have progressed beyond the point where a man will be satisfied with the moderate amount of power that a horse can give, when he is compelled to set aside five acres of land upon which to raise the feed to maintain the horse. He believed that it was possible to use the forces of nature manifested in plant life and obtain power much more economically. When our present stores of fuels are exhausted, he believed we will have progressed to a state of knowledge to enable us to utilize water power in the manufacture of hydrocarbons which can be stored and used for power generation as required.

JOHN T. FAIG,
Section Secretary.

NEW YORK, OCTOBER 10

The opening meeting of the New York Section was held on the evening of October 10, with E. J. Prindle in the chair.

The chairman introduced Dr. Charles L. Reese, Chemical Director of the du Pont de Nemours Powder Co., who gave an instructive address on the subject of Explosives.

Dr. Reese described the evolution of the art of manufacturing explosives for industrial purposes, from the time of the commercial production of black powder to the present. With the aid of samples of explosives and of lantern slides he traced clearly the steps in the manufacture of the nitrocellulose and also of the nitroglycerin classes of smokeless powders, and of dynamite and blasting gelatin and their modifications. He described in detail the various processes under which modern types of high explosives are manufactured.

Dr. Reese followed with descriptions, particularly interesting to mechanical engineers, of the methods of testing explosives for such factors as velocity of detonation, sensitiveness of high explosives, comparative strengths of explosives, etc.

He concluded with an interesting description of the use of explosives for agricultural purposes, illustrating particularly how sub-soil of hardpan is broken up with dynamite, resulting in greatly increased production of crops.

At the close of Dr. Reese's talk several members present put questions to the speaker, which he answered. A unanimous vote of thanks was extended to Dr. Reese for his able address, and the meeting adjourned.

The meeting was preceded by an informal dinner at Offer's Restaurant, where this function will be continued until further notice.

The Section held a technical excursion on October 28 to the Ridgewood Pumping Station of the Department of Water Supply, Gas and Electricity, of the City of New York.

A. D. Blake,
Section Secretary.

MINNESOTA, OCTOBER 12

The Minnesota Section held its second meeting of the season at the St. Paul Gas Light Company's offices in St. Paul, Minnesota, on Thursday evening, October 12, 1916, at which a talk was given by Charles Fortner of the Standard Oil Company, Minneapolis, on the subject Lubricants. This talk was very interesting indeed, and dealt not only with manufacturing processes, but also the conditions governing the proper selection of an oil for any given installation. It was followed by a lively discussion, participated in by most of the members present.

D. M. Forfar,
Section Secretary.

DETROIT, OCTOBER 13

On October 13 a dinner was held by the newly-constituted Section of the Society at Detroit. There were 35 members present. The following officers were chosen by the Section to serve for the coming year: M. E. Cooley, president; E. C. Fisher, T. H. Hinchman, G. W. Bissell and J. W. Parker.

PROVIDENCE, OCTOBER 13

The Providence Engineering Society opened its new rooms on Friday, October 13, with a house-warming. The House Committee has been busy all summer with furnishing and redecorating the rooms, which are rented from the Rhode Island School of Design. Their work has been well done, and with the help of the generous gift of Henry D. Sharpe the rooms and equipment are all that could be desired for a modern club.

The President, Prof. Brookes, of Brown University, took charge of the formalities of the evening, and after an address of welcome, in which he outlined the proposed work of the club for the coming winter, he introduced Ex-Lieutenant Governor Zenas W. Bliss, also a member of the Society, who spoke on The Relation of Engineering to Public Affairs. Following this a collation was served, and a general social time concluded the evening's programme. The spirit of the meeting augured well for the winter's activities of the Society.

Albert E. Thornley,
Section Secretary.

PHILADELPHIA, OCTOBER 24

The Section at Philadelphia had its first meeting on Tuesday, October 24. There was an excellent attendance of both members of the Society and of affiliated clubs.

Professor Wm. Cathcart, formerly of the United States Navy, delivered a most interesting and timely address, illustrated by lantern slides, upon the Development of Our Fleet and Naval Stations. He outlined at the outset the engineer's relation to modern naval war; its structures and mechanisms —its hulls, turbines, guns, dynamos, wireless, torpedoes and aircraft—are his in conception and construction.

Professor Cathcart pointed out that, while America possessed many advantages due to its geographical position, its efficient devices and inventions, its up-to-date fighting facilities and its well-trained navy, the country was decisively at a disadvantage due to the number of its fighting units and the development of its fortification equipment. The speaker believed that our dreadnaughts should be as large as our dry docks.

He described in turn the various strategic situations on our coasts, the use of mines and submarines, marksmanship, naval guns, and the organization and personnel of the Navy.

The very spirited discussion after the meeting showed that engineers nowadays are giving a very important place in their minds to the proper defense of our seacoasts.

W. R. Jones,
Section Secretary.

STUDENT BRANCHES

ARMOUR INSTITUTE OF TECHNOLOGY

A business meeting of the Student Branch of the Armour Institute of Technology was held on September 18. The resignation of L. A. King, president of the Branch, was accepted with regret and C. R. Pomeroy was elected vice-president.

On September 25, a meeting of the Branch was held at which several of the members gave short talks. H. Luttge spoke on Carburetors, O. W. Armspach on Heating and Ventilation and B. Robecheck on the heating and ventilating system at the Armour Institute of Technology.

An open meeting of the Branch was held on October 4 which was devoted to social events.

E. W. Haines,
Branch Secretary.

BUCKNELL UNIVERSITY

A meeting of the Student Branch of Bucknell University was held on October 2. Plans for the season were discussed, and it was decided to have a talk upon some engineering subject by a student at every monthly meeting.

Prof. F. E. Burpee, Mem.Am.Soc.M.E., gave a very interesting talk on the Mechanical Engineering Course, Its Scope and Advantage.

C. M. KRINER,
Branch Secretary.

CARNEGIE INSTITUTE OF TECHNOLOGY

The following officers have been chosen to serve the Student Branch of the Carnegie Institute of Technology for the year 1916-17: Harry A. Madison, president; W. H. Sturgeon, vice-president; J. Davis, secretary; A. L. Heston, treasurer.

HARRY A. MADISON,
Branch Chairman.

LELAND STANFORD JUNIOR UNIVERSITY

A meeting of the Leland Stanford Junior University Student Branch was held on September 13. Following the transaction of business, R. W. Hope, honorary secretary of the American Institute of Electrical Engineers, gave a very interesting talk about his early work as assistant engineer for the project of intercommunication between Europe and America, giving the routing from New York to San Francisco, up the Pacific Coast to Alaska with a short submarine cable across Behring Strait to Siberia, then to Saint Petersburg and from there to London.

A. L. MORGAN,
Branch Corresponding Secretary.

PENNSYLVANIA STATE COLLEGE

The Pennsylvania State Chapter opened the 1916-17 season on September 26 with a preliminary meeting at which the season's programme and committees were announced. This meeting was followed by a social meeting at which the new faculty members were introduced and invited to make addresses. These members include E. A. Fessenden, Professor of Mechanical Engineering; J. W. Haney, Instructor in Mechanical Engineering, and J. O. Keller, Instructor in Industrial Engineering, members of the Society.

HUGO DIEMER,
Branch Corresponding Secretary.

POLYTECHNIC INSTITUTE OF BROOKLYN

The opening meeting of the Polytechnic Institute of Brooklyn Student Branch was held on October 7. Arthur Bielek, chairman of the Branch, presided, and told what the Branch had accomplished in the year just past and what it expected to do during the coming year.

At the close of the business meeting Arthur Seubert, Mem. Am.Soc.M.E., gave a paper on Chlorination and Water Purification. Mr. Seubert traced the history of water supply from the time of the Roman Empire to the present day. He said that while the Romans had built a complex and reasonably sanitary system of water supply, the people of the middle ages made no attempt to purify the water or investigate the source of their supply of drinking water.

He then discussed the use of the sand filter from the early days in London to modern times, and also spoke of the impurities in water which cannot be removed by filtering. He pointed out that the best method of removing these impurities is by injecting fine particles of chlorine into the water.

The speaker described the apparatus designed by the Wallace and Tiernan Company for chlorinating water, and illustrated by the use of lantern slides the application of the apparatus to many water-supply systems.

FRANK R. STAMER,
Branch Secretary.

PURDUE UNIVERSITY

On September 29, the Student Branch of Purdue University held an open meeting for the purpose of increasing acquaintanceship among the new students in mechanical engineering. Dean Benjamin, Mem.Am.Soc.M.E., and Professor Young, Mem.Am.Soc.M.E., discussed the relation of the Student Branch to the Society and the value of The Journal to members of the Branch.

G. A. RUESS,
Branch Corresponding Secretary.

UNIVERSITY OF ILLINOIS

The University of Illinois Student Branch opened the semester's work on Thursday evening, September 28. About seventy-five members were present, which is an indication of activity.

Dean Goss, Past-President Am.Soc.M.E., addressed the meeting, his theme being A High Standard for the Engineering Profession. He urged the members to be active in the affairs of the Branch, pointing out that the activity of each member would be reciprocal in benefiting both the Branch and the member.

A new recording secretary, H. O. Isaacson, was chosen to succeed R. N. Foster, and R. Rahn was appointed representative to the *Technograph,* the Engineering Societies' publication. tion.

The treasurer's report showed a membership of over a hundred and a substantial account in the bank in the Branch's name. Two committees were appointed, for advertising meetings and for soliciting subscriptions for Branch pins respectively.

Plans are being formulated for the delivery of several student lectures, so that the work of the Branch for the semester is very promising.

V. S. DAY,
Branch Chairman.

WORCESTER POLYTECHNIC INSTITUTE

At the last meeting of the school year of the Worcester Polytechnic Institute Student Branch held on June 1, the following officers were elected for the year 1916-17: John A. C. Warner, chairman; Charles Hollerith, vice-chairman; Earl R. Knight, treasurer and Franklin T. Holmes, recording secretary. Following the election, abstracts of several of the students' theses were read and discussed. Arthur Nutt presented a paper on Thermostatic Control of Jacket Water in Automobiles, Aurelio E. Zamberano on Automobile Acceleration, and Arthur K. Ingraham on Tests of Ammonia Safety Valves.

The first regular meeting of the Branch for 1916-17 was held on October 6, at which F. E. Stanley, of the Stanley Motor Carriage Co., Newton, Mass., gave an illustrated lecture on Steam-Propelled Vehicles.

Mr. Stanley related how he first became convinced of the possibility of driving a 4-wheeled carriage by steam propulsion, and told of overcoming the various difficulties which presented themselves at the first trials of his steam-driven automobiles. He described fully the functions and details of the fire regulator, fuel pump, steam and water gages, as well as other major mechanisms of the car, each mechanism illustrating the solution of the engineering problems which he and his company encountered in the car's early career. He also described the company's new car, in which the engine is run condensing, and gave figures showing its efficiency. He concluded with slides illustrating the main points of difference between the latest model of the Stanley Steamer and its predecessors.

Mr. Stanley then read extracts from a biographical paper of the life and accomplishments of George Stevenson, who is credited with having designed the first practical locomotive.

H. P. FAIRFIELD,
Branch Secretary.

The American Association for the Advancement of Science and some thirty national scientific societies affiliated with it will meet in New York City during the last week in December, 1916, under the auspices of Columbia University, New York University, the College of the City of New York, the American Museum of Natural History and other scientific and educational institutions. Dr. C. R. Van Hise, president of the University of Wisconsin, will preside.

EMPLOYMENT BULLETIN

THE Secretary considers it a special obligation and pleasant duty to make the office of the Society the medium for assisting members to secure positions, by putting them in touch with special opportunities for which their training and experience qualify them, and for helping anyone desiring engineering services. The Society acts only as a clearing house in these matters.

POSITIONS AVAILABLE

In forwarding applications, stamps should be enclosed for transmittal to advertisers; applications from non-members should be accompanied by a letter of reference or introduction from a member, such reference letter to be filed with the Society. Copy for notices must be in hand by the 18th of the month.

ASSISTANT ENGINEER for preparation of plans and specifications and supervision of installation of electric lighting, steam-heating and ventilating systems in buildings of Eastern University. Some installations are in new buildings and others involve remodeling of present buildings. Wide variety of work and position offers excellent opportunities for experience. Salary $75 to $90, depending on experience. 559

YOUNG MAN for engineering computation department and answering engineering correspondence. Technical education preferable. Location Massachusetts. 560

PRACTICAL ENGINEER experienced in handling machinists, pipe fitters and electricians. Salary $1800 to commence. Good opportunity for advancement. Location New York. 562

EXPERIENCED MAN to take charge of manufacture of soap powder. Salary $30 to start. Location New York. 563

DRAFTSMEN for Stoker Department. Work involves making layouts of stoker installations and also requires general knowledge of boiler-room work for concern manufacturing specialty. Good draftsmen with some knowledge of this class of work more valuable than good designers. Salary up to $25 weekly to start, depending on ability and experience. Location Philadelphia. 565

SUPERINTENDING OPERATING ENGINEER, technical graduate, for plant making pipe coverings. State salary desired, experience, etc. Location N. J. Apply by letter. 567

DRAFTSMAN, experienced in rolling mill machinery, etc. Salary $150. Location Easton, Pa. 571

YOUNG MAN, preferably '15 graduate, for general office, drafting and purchasing work, with opportunity to sell special chemical apparatus. Salary $20 per week to start, with opportunity to make additional money on profit-sharing basis on sales. Location New York. 575

ASSISTANT DIRECTOR of shop laboratories, department of mechanical engineering of prominent university. Salary $1800. College graduate who has had some direct connection with organization work and development of manufacturing methods in thoroughly modern plant; requires excellent personality, possessing initiative and ability. Considerable possibility for future. 576

INSTRUCTOR or ASSISTANT PROFESSOR in mechanical engineering, to teach thermodynamics, steam engines, boilers and power plant design. Preferably man who has had some experience in engineering in connection with power plants. Applicant must be available immediately. Salary $1200 to $1500 according to experience and training. Location Pennsylvania. 577

CHIEF DRAFTSMAN, experienced, for manufacturer of automobile parts. Location New Jersey. 587

CHECKER on drawings for manufacturer of automobile parts. Location New Jersey. 588

DESIGNER of jigs, tools, special machines, for manufacturer of automobile parts. Location New Jersey. 589

MECHANICAL DRAFSMAN for general factory work to lay out work of a general character and be a leader and direct others in the drafting room. Familiar with conveying systems, power plant equipment, steam heating and electrical equipment. Salary $110 per month to start, with opportunity for advancement for right kind of man. Location Newark, N. J. 590

ENGINEER, capable of handling detailers and tracers and production in shop; experienced in manufacture of large machinery. State age, technical training, experience, salary expected and give reference. Location New York. 591

SUPERINTENDENT of construction for power house. Salary depends on man. Location New York. 592

YOUNG MAN, ambitious and energetic for maintenance and construction department of large corporation in Middle West. Experienced in handling men, plant engineering and operation, such as installation of machinery and shafting, construction and maintenance of buildings, including carpentry, steam fitting, painting, plumbing, masonry and electrical work, as well as power plant operation. Opportunities for advancement exceptional. State age, education, previous and present employment, full details of experience and salary expected. All correspondence strictly confidential. 593

PUBLICITY ENGINEER, technically trained, with experience in building construction and if possible general acquaintance with power-plant engineering. Must have demonstrated ability to write technical and popular matter for publication. Both editorial and reportorial experience desirable. Permanent position assured to the right man. 594

ASSISTANT SUPERINTENDENT for munitions plant producing high explosive shells. Location New York State. 600

DESIGNER of machine tools, preferably with experience in design of tools for shell work. Location New York State. 601

YOUNG ASSISTANT ENGINEER, preferably technical graduate, Christian, to act as assistant to engineer of service department. Location New York. 603

THREE MEN competent to devise and take charge of the installation of cost and production systems. Work near Boston, New York and Chicago. State age, salary, experience and references. 615

CADET ENGINEER, technical school graduate preferred. Good opportunity for young engineer. Location New Jersey. 616

YOUNG MAN for drafting and record work. Location New Jersey. 617

ENGINEERS for production department of plant manufacturing steel-plate receptacles of all sizes and shapes. Prefer men with tecanical education, fair draftsmen, with experience in industrial plants in connection with production, working knowledge of routine, scheduling, time study, etc. All correspondence strictly confidential. In first letter state age, experience, married or single, and salary expected. Location New York State. 618

DISTRICT SALES MANAGER. Established firm desires sales manager to take charge of new office in Cleveland, O. Competent to sell stokers and other steam equipment. Salary and commission. First letter must state—whether employed at present; experience and education; reasons for leaving last three positions; reasons for answering this advertisment; age, married or single, height, weight and complexion; recent photograph if possible (enclose stamp for return); present salary; knowledge of Cleveland territory, if any. 619

TECHNICAL EXPERT, familiar with manufacture of grindstones. Prominent French firm about to engage in manufacture of specially shaped grindstones as side line, requires first-rate technical man in its establishment in France. Must be thoroughly conversant with every detail of the industry. Excellent permanent position to right man. Knowledge of French unnecessary. State qualifications, age, salary desired, etc. 620

DRAFTSMAN on agricultural machinery. Salary $125 and living quarters. Position in Santiago, Cuba. 621

DRAFTSMAN in engineering department of paper mill. Should have experience in machine work and be able to do any class of drawing from notes or free-hand sketches. Speed is the principal requirement. Location central Massachusetts. 622.

MECHANICAL or ELECTRICAL ENGINEER, technical graduate, with best personal qualifications for integrity and sobriety, good understanding of principles of mechanics and general fundamental knowledge of main elements of electrical engineering. Must also be capable surveyor. Work will be in development of range-finding instruments. 624

GENERAL SALES CORRESPONDENT. Engineering and correspondence experience such as involved in formulating proposals covering sale and calculation of size adaptation in steam and power-driven pumping equipment of displacement types, including application of steam engines, combustion engines and electrical equipment that may be employed. Applicant should supply references bearing upon a record as correspondent, capable of formulating propositions of character indicated, proper closing of contracts, execution of orders and closing of accounts. Salary not less than $2500. Location Ohio. 627

SUPERINTENDENT, to take active control of modernizing old established manufacturing plant, including pattern shop, foundry, machine shop, etc.; unusual opportunity for young man 30 to 35, with thorough experience and strong personality, who can firmly and quietly get results. Location Missouri. 628

MECHANICAL DRAFTSMEN and DESIGNERS familiar with power plant and factory layouts. Location Boston. 629

ENGINEER, practical as well as theoretical, to have charge of tubing mill manufacturing brass covered steel tubes, welded steel and brazed tubing. Salary depends on man. Location New York. 633

MEN AVAILABLE

Only members of the Society are listed in the published notices in this section. Copy for notices should be in hand by the 18th of the month, and the form of the notice should be such that the initial words indicate the classification. Notices are not repeated in consecutive issues.

MECHANICAL ENGINEER. Designer of high-speed automatic machinery. Executive ability. Ten years' experience. Desires position in vicinity of New York or Newark. At present employed. K-363

MECHANICAL ENGINEER and DRAFTSMAN. Chief draftsman or assistant superintendent. Technical graduate. Age 36. Thirteen years' experience. Familiar with manufacture of water-gas, soaps, leather belting, coal-mining and handling machinery. At present employed. Salary $1800 to $2400. K-364

SALES ENGINEER, mechanical-electrical, American, age 34. Eleven years' experience in selling electrical and mechanical machinery and supplies. Executive ability. Speaks Portuguese, Spanish and German. Just returned from Brazil. Desires position as representative or branch manager for South America or Cuba. K-365

MECHANICAL ENGINEER, technical graduate, American. Sixteen years' experience designing and estimating on Corliss engines, hoisting engines, air compressors, gas engines, pumps. Two years' experience answering correspondence and selling. Open for responsible position. Middle West preferred. K-366

REPRESENTATIVE. Engineer having his own office in New York City desires to secure additional representation on commission basis for out-of-town manufacturer. Graduate M. E. Cornell University. K-367

COMBUSTION ENGINEER and SMOKE ABATEMENT EXPERT, at present completing 4-year term as chief smoke inspector of large city, wishes connection with stoker or boiler concern or on special city smoke-abatement work. K-368

FUEL TESTING ENGINEER. Graduate, age 34, seven and a half years' experience in scientific testing of coal in industrial plants, for large coal company in Middle West. Desires position as combustion engineer for large user of coal. At present employed. K-369

COAL TESTING and SALES ENGINEER. Graduate, experienced in scientific testing and selling of coal. Desires position as sales manager for coal-operating company. At present employed. K-370

MECHANICAL ENGINEER. Graduate M. E. Four years' experience in boiler design and kindred work. Seven years in large rubber manufacturing plant as assistant engineer, inaugurating many labor-saving schemes, conveyors and plant layouts. Familiar with shop management along scientific lines, time-study system. Tactful, good organizer and good executive. Capable of taking full charge responsible work. K-371

PRODUCTION ENGINEER. Technical graduate with thorough shop training. Experienced in time-study work and investigations. Familiar with cost-routing and store-keeping systems. Able to obtain increased production and decreased costs. K-372

MECHANICAL SUPERINTENDENT or MASTER MECHANIC. Associate-Member, 39. Extensive experience in entire charge of machine shops, also erection and test in field manufacturing all sizes surface and jet condensers, engines, high-vacuum air and centrifugal pumps, heaters, etc. Competent to take entire control of machine shops in any line of manufacture. Good executive. Excellent references. Will go anywhere. K-373

EXECUTIVE ENGINEER, familiar with experimental engineering. Twelve years' practical experience in designing and operating industrial plants and large power stations. Age 34, married. Salary $2500 to start. K-374

NAVAL ENGINEER. Stevens graduate, with fourteen years' experience in marine engine designing, steam, gasoline and Diesel as well as other general designing required in shipyard work. Desires to make change. K-375

MECHANICAL ENGINEER, ten years experience in machine shops and engine works, fifteen years in present position as head of a known engineering school, desires change. Summer vacations have been spent on engineering staffs of prominent concerns. Responsible position with manufacturing or consulting engineering firm or executive position with high-grade school of technology will be considered. East preferred. K-376

RAILWAY MECHANICAL ENGINEER at present employed as mechanical engineer. Age 37, technical education, seventeen years' experience as railway machinist, draftsman, chief draftsman and mechanical engineer; desires mechanical engineering position with railway company, railway supply house or industrial plant with greater responsibility and opportunity. Location immaterial. Salary $2400. K-377

CHIEF ENGINEER or CHIEF DRAFTSMAN. Technically-trained engineer, sixteen years' experience in steel works, blast furnace and steam power plant work, designing, testing and investigating, seeks opportunity for advancement. Age 39. At present employed. References furnished. K-378

PUBLIC UTILITIES EXECUTIVE. Associate-Member. Technical graduate. Ten years' experience in designing, inspecting, as construction superintendent, operating superintendent, assistant chief engineer; one and a half years as mechanical designing engineer for large public utilities corporations. Desires position as general manager of utilities or construction or designing engineer for large holding company. At present holding position with large corporation supervising all mechanical construction. Minimum salary expected $3300. K-379

MECHANICAL ENGINEER. Junior-Member, Cornell graduate, age 28. Six years' experience testing, executive work and selling. Now employed but desirous of making change. Has good record. K-380

ASSISTANT TO EXECUTIVE or SALES MANAGER. Technical graduate, age 36, desires change. Experience in testing, research, designing and commercial engineering, in connection with steam turbines, turbo-blowers and centrifugal pumps, with responsible charge of men. New York City or eastern location preferred. K-381

CHIEF DRAFTSMAN or MASTER MECHANIC. Ten years' experience in manufacture of interchangeable parts; thoroughly experienced in design of punch and dies, jigs, tools, fixtures, special and automatic machinery for manufacturing parts on interchangeable basis. Location preferred in or vicinity of New York City or Newark. K-382

EXECUTIVE or MECHANICAL ENGINEER, experienced in organization, design of special, and elevating and conveying machinery. Technical graduate. At present employed. Desires interview with parties seeking reliable, aggressive man for responsible position. Location New York or vicinity. K-383

MECHANICAL ENGINEER. Junior-Member, technical graduate, age 32, married. Five years' experience in design, installation and operation of mechanical equipment of coal mines, including boiler plants, pumping and ventilating plants; machine shop experience. Desires position with a future. K-384

STEAM ENGINEER. Can design, build and operate first-class power plants. Age 40. Can make change about January 1, 1917. K-385

ASSISTANT TO EXECUTIVE or CONSULTING ENGINEER. Cornell graduate. Mechanical and electrical engineer. Associate-Member. Age 31. Nine years' experience, six years in charge. K-386

PURCHASING or INSPECTING ENGINEER. Eight years' experience in inspection and purchasing of all classes of engineering material for leading railroads and U. S. Government; wide acquaintance and familiar with all largest industrial plants and sources of supply throughout the country. Thoroughly experienced in the purchasing, testing and inspection of steel structures, railroad and industrial supplies, etc. Age 30, college graduate, now employed. K-387

SALES or ASSISTANT TO EXECUTIVE. Graduate M. E. from prominent university; ten years out of college, with six years' experience in general sales office of steel foundry. Desires responsible posi-

tion in general sales or executive office, preferably in Middle West. K-388

EXPERIMENTAL ENGINEER, for mechanical laboratory and research work. Graduate M. E., shop and long engineering experience in Germany and United States. Last six years in scientific experimental research work. Desires permanent position with private firm or consulting engineer. Specialty heat and combustion, calorimetry, fuel economy, measuring apparatus. K-389

MECHANICAL ENGINEER, over 20 years' experience on construction, maintenance and manufacture in connection with power plants, mining, machine tools, arms, ammunition, engines, boilers, gas machinery and engines, turbines, paper, jute. At present finishing up power construction work; will be available about December 1. Location desired in or near New York. K-390

ENGINEER-EXECUTIVE, experienced in design, construction and operating quarries, chemical, and ore-dressing plants. Age 39. Good executive. Prefers development work in West or South. Now employed near New York. Salary $7500 or equivalent. K-391

ROLLING MILL ENGINEER. Technical graduate. Ten years' thorough experience, having full charge of design of rod mills, continuous and looping, flat, billet and reversing mills, also complete wire mills, furnaces, etc. Desires position as chief or assistant chief engineer or in other responsible capacity. K-392

TECHNICAL GRADUATE, Junior-Member, age 27, experienced in operation, construction and maintenance of small power plant with test work on boilers up to 300 h. p. Location not essential. K-393

MECHANICAL or CHIEF ENGINEER, fifteen years' experience in designing, shop and executive work. Systematic and reliable. Capable of assuming responsibility and handling men. Inventive ability. Resourceful designer of automatic labor-saving machinery. Research, experimental and development work. Can report immediately. K-394

MECHANICAL ENGINEER and CONSTRUCTION SUPERINTENDENT. Associate-Member. Graduate M. E., eight years experience supervising complete layout, purchase, construction and maintenance of mechanical and electrical equipments for factories and mercantile buildings. Can handle men and get results. Desires position with industrial building concern. Middle West preferred. K-395

MECHANICAL ENGINEER, age 32. Ten years experience teaching machine design, safety inspection of factories, drafting and engineering on commercial motor vehicles. Desires position as engineer or assistant engineer with manufacturer of motor cars, accessories, or special machinery. New York or vicinity. K-396

RESIDENT ENGINEER, SUPERINTENDENT OF CONSTRUCTION, general superintendent or manager of industrial plants. Age 40, 19 years engineering and executive experience. Salary $3,000 to $6,000 depending on position offered. Salary last two years $6,000 per year. Available at once. K-397

ACCESSIONS TO THE LIBRARY

A List of Books and Pamphlets Added During the Past Month to the Library of the Society and of the United Engineering Society, Engineering Societies Building, New York

LIBRARY NOTES

The actual moving of the library of the American Society of Civil Engineers to the United Engineering Societies Building awaits the purchase of additional shelving.

The consolidation of this collection with the joint library will make the latter the most important of its kind in the world. In addition to the many sets of periodicals which are new to the U.E.S. Library and the very important sets of Government, State and Municipal reports which will come from the Civil Engineers, there is an extensive collection of pamphlets, maps and specifications. Reorganization of the collection will take some time, but is being carefully planned.

The periodicals and society publications currently received in the Library of the Engineering Societies now number over 1100, published in 32 countries and in 11 languages.

Attention of the membership is called to the "Catalogue of Technical Periodicals in the Libraries of New York and Vicinity," published recently by the Library. This lists, with full catalogue entry, about 2500 technical periodicals, and tells where they are to be found. Changes of title, discontinuances, and indexes are noted. When it is remembered that any article in these periodicals can be furnished in an accurate photostat copy, the value of the catalogue to the engineering student is manifest. Copies are sold by the Library for three dollars, postpaid.

The Library is very anxious to obtain all the trade catalogues in engineering lines, and the coöperation of members in rendering assistance in this direction is requested. Catalogues are carefully analyzed for the use of readers.

ADDITIONS BY THE SOCIETY

Air Brake Association. Proceedings of 23d annual convention, 1916. *Atlanta, 1916.* Gift of Air Brake Association.

American Society of Mechanical Engineers. Condensed Catalogues of Mechanical Equipment, with general classified directory. *New York, 1916.* Gift of A.S.M.E.

Carnegie Endowment for International Peace. Year Book, 1916. *Washington, 1916.* Gift of Carnegie Endowment for International Peace.

Chemical and Biological Survey of the Waters of Illinois. Report for year ending Dec. 31, 1914. Water Survey Series no. 12. *Urbana, 1916.* Gift of A.S.M.E.

Citizenship Syllabus. Reprinted from 12th Annual Report of the N. Y. State Department of Education. *Albany, 1916.* Gift of C. W. Rice.

Climatic and Living Conditions at Various Centers, Geo. H. Davis. *New Orleans, 1916.* Gift of G. H. Davis.

Fowler's Mechanical Engineer's Pocket Book, 1916. Eighteenth annual edition. *Manchester, England, Scientific Publishing Co., 1916.* Price 2s. 9d., post free. Gift of publisher.

Fowler's Electrical Engineer's Pocket Book, 1916. Sixteenth annual edition. *Manchester, England, Scientific Publishing Co., 1916.* Price 2s. 10d., post free. Gift of publisher.

These two little pocketbooks of about 500 pages each have a large sale in England, and should appeal from their varied contents and their low price to engineers in this country.

W. P. C.

Linear Hot-Wire Anemometer and Its Applications in Technical Physics, L. V. King. Reprinted from Franklin Institute Journal, Jan. 1916. *Philadelphia, 1916.* Gift of author.

Looking Squarely at the Waterpower Problem, H. J. Pierce. Gift of A.S.M.E.

New Jersey. Board of Public Utility Commissioners. Financial and miscellaneous statistics compiled from the annual reports made by Public Utilities, 1914. *Union Hill, 1916.*

——— Annual Report, 1915. *Trenton, 1916.* Gift of Board of Public Utility Commissioners.

New York City. Board of Water Supply. Contract 174—Information for bidders, forms of proposal, contract, bond and certificates, specifications and drawings for furnishing, delivering and installing riser-valve controlling mechanisms and appurtenances in the shafts of the city tunnel of the Catskill Aqueduct. *1916.*

——— Contract 178—Information for bidders, forms of proposal, contract, bond and certificates, specifications and drawings for grouting a portion of the Eastview Tunnel of the Catskill Aqueduct, in the town of Mount Pleasant, Westchester County, N. Y. Gift of Board of Water Supply.

New York State Engineer and Surveyor. Supplement to the Annual Report, Vol. II, 1915. *Albany, 1916.* Gift of New York State Engineer and Surveyor.

Ownership of Invested Earnings or Invested Surplus, Samuel S. Wyer. Gift of author.

On Some Proposed Electrical Methods of Recording Gas Flow in Channels and Pipes Based on the Linear Hot-Wire Anemometer, L. V. King. *Philadelphia, 1916.* Reprinted from Franklin Institute Journal, August 1916. Gift of author.

Railway Regulation and Locomotor Ataxia, Frank Trumbull. *New York, 1916.* Gift of Railway Executive Advisory Committee.

A Work on the Conservation of Water by Storage, Geo. F Swain. Gift of A.S.M.E.

EXCHANGES

Brooklyn Engineers' Club. Proceedings, 1915. *Brooklyn, 1915.*

TRADE CATALOGUES

Flannery Bolt Co., *Pittsburgh, Pa.* Staybolts. *September, 1916.*

Greenfield Tap & Die Corporation, *Greenfield, Mass.* Catalogue no. 37. Gages, taps, dies.

Greenfield Tap & Die Corporation, *Greenfield, Mass.* The "Gun" tap. 12 pp.

Leschen, A. & Sons Rope Co., *St. Louis, Mo.* Leschen's Hercules. *September, 1916.*

Sleeper & Hartley, Inc., *Worcester, Mass.* Bulletin no. 252. Helical bed spring coiling machine. *March, 1915.*

——— 254. No. 2 Universal coiler. *April, 1915.*

——— 264. Spring setting machines. *April, 1916.*

——— 267. Automatic tube straightening machines. *June, 1914.*

——— 268. Helical cutting and hooking machine. *March, 1915.*

——— 269. Wire nail machines. *December, 1914.*

——— 270. Torsion spring machines. *July, 1916.*

——— 272. Music wire straightening and bundling machines. *June 1915.*

——— 275. No. 1 wire rolling and flattening mill. *November, 1915.*

——— 277. Spring hooking machines. *November, 1914.*

——— 280. Special spring coiling machines. *June, 1916.*

——— 287. Furniture spring coiler. *June, 1916.*

——— 288. No. 0 and No. 1 Universal coilers. *May, 1916.*

——— 306. No. 4 Universal coiler. *August, 1916.*

——— 308. Flexible shaft coiling machine. *May, 1916.*

——— 309. Flexible metallic tube coiling machines. *May, 1916.*

——— 318. No. 3 Universal coiler. *January, 1916.*

——— 319. Flexible casing coiler. *May, 1916.*

——— 326. No. 5 Universal coiler. *August, 1916.*

List of standard machines offered to the trade.

Texas Company, *New York City.* Lubrication. *September, 1916.*

Walworth Mfg. Co., *Boston, Mass.* Walworth Log. *September, 1916.*

Whiting Foundry Equipment Co., *Harvey, Ill.* A model foundry, no. 125.

ADDITIONS BY THE UNITED ENGINEERING SOCIETY

Abstracts of Current Decisions on Mines and Mining, Reported from January to April 1916. U. S. Bureau of Mines. Bulletin 126, *Washington, 1916.*

American Express Company. Foreign Trade Building. *October 1915.* Gift of American Express Co.

American Foundrymen's Association. Year Book, 1916. *Cleveland, 1916.*

American Iron & Steel Institute. Annual Statistical Report, 1915. *New York, 1916.*

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ENGINEERING SURVEY

A Review of Engineering Publications in All Languages. All the leading periodicals of the engineering world, embracing over 1000 different publications, are received at the Library. These are systematically examined for review each month in the Survey.

SUBJECTS OF ABSTRACTS

Arranged in the Order of Their Appearance in the Survey.

In this issue of the Engineering Survey will be found two groups of articles related not inherently but by their bearing on the existing situation. Howard E. Coffin's article on munitions manufacture on the one hand and several articles on scientific research in relation to industries on the other would have been regarded three years ago as relating to entirely independent subjects. Today military preparedness for the defense of the country against armed aggression, and industrial preparedness vitally necessary to assure a country its due place in the world's market, have brought them into essentially the same class.

It is, however, more and more fully realized that no industrial progress, which is the corner stone of industrial preparedness, is possible without the closest correlation between the developments of science and their application to industrial engineering. Unless the achievements attained today in the laboratory in any country are transferred to the shop, it is fairly certain that some other country will avail itself of them and secure a hold on the market.

Events of the last two years have taught this lesson in a very striking manner. The world's industries have suddenly found themselves lacking not only sources of supply of some staple materials, but even, in many instances, knowledge of how these staples are produced. No country intends to repeat this error, and the papers by Coffin and Carty prove conclusively that in this country there is a full realization of this fact.

Those interested in the present industrial problems here will also be interested in how matters stand abroad, and in this issue will be found two highly authoritative statements on the situation in France by A. Blondel, Member of the French Academy of Sciences, and on the work and prospects of the National Physical Laboratory in England by Walter Rosenhain, chief of one of the departments and a metallurgist of note. Bearing on this same subject, is a paper by Charles P. Steinmetz, chief consulting engineer of the General Electric Co., read on October 18, 1916, before The Franklin Institute at Philadelphia, delivered too late to be abstracted in the Survey. The speaker said that since established research institutions have not been able to furnish all the information desired for use in the industries, industrial establishments have recently gone into scientific research themselves with vastly extended facilities, with the result that of late the largest number of scientific advances have been made in industrial research laboratories. Germany was first to realize that the establishment of the industrial research laboratory was one of the most profitable investments which could be made by the large industries, but in the last few years American corporations have also fully awakened to a realization of this fact, and the research laboratories established in this country by industrial corporations are doing scientific work of the highest order in chemistry, physics and mechanics.

THIS MONTH'S ARTICLES

In the section Aeronautics will be found an interesting report of a session of the Executive Committee of the National Advisory Committee for Aeronautics, devoted mainly to the discussion of means for securing satisfactory motors for American aircraft. The discussion brought out several highly important points. It showed that the details of design and construction are far from receiving a proper amount of attention. The wiring is in many cases defective. Installation of magnetos is such as has been long ago abandoned, for example, on racing cars. Another important point brought out is the growing conviction of designers as to the influence of

engine vibration on the general factor of reliability of the machine. Discussion has also confirmed the prevailing impression that big motors of 200, 300 and perhaps higher horsepower, will be especially demanded in the near future.

A. R. Braden describes a method of making cast-iron drop-forge dies which proved successful on shoe-machine forgings. The main improvements appeared to be in the method of producing the patterns.

In the section Engineering Materials will be found two advance abstracts of technologic papers of the Bureau of Standards, published by courtesy of the Bureau. One of these abstracts is devoted to an investigation of a homogeneous alpha brass, presenting an interesting explanation of the decrease in strength and ductility of brasses when corroded while under stress.

The other Bureau of Standards' investigation covers a petrographic study of various porcelains, as well as combinations of the raw materials which enter into porcelain manufacture. It is found that the constitution and microstructure of porcelain depend upon the temperature of burning, the time of burning factor being only of secondary importance. The petrographic and microscopic study of porcelain of the type carried out at the Bureau is of high importance, in that it places the chemical and physical properties involved in the formation of porcelain on a more quantitative thermal basis. Furthermore, it offers a means of estimation of burning temperature of a ware from the examination of a fragment much too small in size to be satisfactory for even a chemical analysis.

Data on stresses produced by burning-in manganese bronze are presented by D. Merica and C. P. Karr from an investigation made in connection with some work on manganese bronze valve castings used in the Catskill viaduct.

Data on the testing of refractories are presented by A. V. Bleininger from work done at the Bureau of Standards.

Several years ago the Missouri, Kansas & Texas Railroad decided to install pulverized coal firing for some of their stationary boilers. For various reasons the installation was not put into operation until this year. Since then various tests have been made with different fuels and all of them burned with entire success and without troublesome deposits of ash. The abstract in the section Fuels gives a brief description of this installation and cost data from some of the tests.

Annealing furnaces operating on the surface combustion principle are described in the section Furnaces. One of their advantages is that they give a neutral or reducing atmosphere which makes it possible to treat forgings without packing.

Prof. W. H. Watkinson's paper presented to the Newcastle meeting of the British Association in September, 1916, will come as somewhat of a surprise to Diesel engineers. The author claims that it should be as easy to obtain ignition temperature by compression to 2 atmospheres as it is to obtain it in the ordinary way by compression to 34 atmospheres, and he shows that it is entirely unnecessary to permit starting period pressures running as high as 800 lb. per square inch.

William C. Glass describes a method of producing parallel depth bevel gears on a universal gear cutter requiring only two settings to complete the gear.

The precision of liquid-measuring pumps is discussed by F. J. Schlink in a paper before the Annual Conference of Weights and Measures of the United States. The conclusion of the author is that nearly all of the defects of construction and installation of gasoline-measuring pumps tend to produce errors in the one direction of under-measurement.

In the section Railroad Engineering will be found a general paper by George M. Basford on electric problems that demand solution, as well as a paper on the Tilling-Stevens gasoline-electric cars to run on standard track. In the same section will be found an abstract of a report made by James E. Howard, engineer physicist of the Interstate Commerce Commission, covering the subject of initial stress in steel rails.

The testing of thermal insulators is the subject of a paper based on the work done at the Bureau of Standards by H. C. Dickinson and M. S. VanDusen. Among other things the paper contains definitions of several terms used in refrigerating engineering and thermodynamics.

Interesting experiments on boiler expansion and certain boiler troubles made on the New York Central lines are described in a paper by D. R. MacBain in the section Steam Engineering.

Aeronautics

Aeronautical Engines

Abstract of a report of a session of the Executive Committee of the National Advisory Committee for Aeronautics held at the Smithsonian Institution, June 8, 1916.

The meeting was held in the very rooms where Dr. Langley first developed his idea of the physics of the air and the art of flying.

Henry Souther, Mem.Am.Soc.M.E., Consulting Engineer of the War Department, stated that we in this country are in a fair way to obtain a satisfactory motor for aircraft within a reasonable length of time, but the only way of arriving at anything of this nature is by a slow process of evolution or use. What is demanded of an aeronautical motor is, in the first place, reliability, which does not, however, necessarily mean anything unusually strong, but means thoroughness in all details of which reliable wiring is an example; accidents may come from an accumulation of gasoline in the shape of a puddle somewhere in the structure, hence the piping is as important as anything, etc.

Next come dependability and durability. Of exceeding importance is also simplicity of design. Adaptability of the motors is a quality that will change as fast as the art changes, and what is considered adaptable today may be viewed as bad practice ten years from now.

Lieut. W. G. Child, U. S. N., in discussing the experience of the Navy with motors, pointed out some matters of considerable practical importance. One is the question of interchangeability of motors. At present beds built for one motor are often not adaptable to another motor of the same horsepower because of the difference in the brackets. One way of overcoming this without changing the design is to make the brackets wider, say 4 in., and not drill bolt holes, so that any motor can be installed on foundations that would take the width of that bracket.

For motors of higher horsepower, the speaker advocated generator ignition because of the necessity of having starters and of the need for a hot spark at low speed. As between having a large lower crank case to keep the oil or of having separate tanks, the preference of the speaker was for separate tanks which would lighten the engine, give an extra oil supply, help cool the oil and permit of installing the tank at any convenient place. In addition, with only a little oil in the motor, there would be no danger of flooding the cylinders in gliding.

One of the greatest problems in aviation is the design of a suitable radiator. The resistance of the radiator means a tremendous loss in lifting capacity, and the Navy found ex-

perimentally that one type of radiator had a very low resistance and was about five times as effective as another type in very general use.

Lieut.-Col. George O. Squier, U. S. A., in charge of the Aviation Section, War Department, stated, in answer to questions, that the Green engine is the one which the British are widely using. It is built in sizes as large as 250 h.p., and two of these are put on an aeroplane. In all the belligerent countries they are doing wonderful things every day, things we have never done here.

Capt. Mark L. Bristol, U. S. N., Commander of the Navy Air Service, believes that we have not a motor in this country suitable for aeronautic use. The principal fault with our motors is that they are unreliable. Another is that we cannot get enough power out of them for naval use. The aeroplane that will be taken to sea must not weigh less than 6000 lb. and must have 300 or 400 h.p. at least. This can be obtained from two motors of from 150 to 200 h.p. each, but there is not such a motor in the United States at present that is reliable.

Charles M. Manly (Curtiss Aeroplane and Motor Corporation) discussed the manner of approach in the matter of developing the best aviation motor. There are two main ways of approaching the subject; one is to start with your motor light weight, and by a process of evolution make it more and more reliable; the other is to start with the motor very reliable and decrease the weight. The speaker personally believes that the better plan is to start with the motor light.

Howard E. Coffin, Mem.Am.Soc.M.E., of the Naval Consulting Board, expressed his opinion that the whole development of aviation has been thus far an experimental proposition only, and that there has been practically no real quantity or commercial production in that line. So far an attempt has been made to build motors which are so near the ragged edge in strength of parts, reliability, lightness, and so forth, that we have got into a lot of trouble that we should be able to avoid. A great deal of the trouble was because of the magneto not being properly mounted on the motor, although we learned in racing cars as early as 1906 that no magneto should carry a gear directly on its shaft. The wiring in the average aeroplane is a joke. All wiring must be carried in metal conduits. In fact, the speaker believes that the wiring of either an automobile or an aeroplane should pass an examination similar to the underwriters' examination by the insurance companies. If a $500 garage is not built without the underwriters passing on the wiring installation, there is no reason why an aeroplane costing $10,000, in which one risks his life, should escape such inspection.

The speaker strongly emphasized the question of the elimination of vibration, which in his belief is the real cause of possibly nine-tenths of the trouble with any apparatus, whether it is a motor car or an aeroplane. The vibration in a gas engine is dependent upon certain fundamentals of its design, and the six- and twelve-cylinder machines are the only two types of engines that in a practical way can be freed from vibration.

It is surprising to find that a six-cylinder engine, if driven by an electric motor so that the engine itself is not running under its own power at speeds up to 2000 to 3000 r.p.m., can be stripped of everything down to the crankshaft without appreciably reducing the noise, which indicates that the principal difficulties in the gas engine are connected in some way with the crankshaft. It makes no difference how heavy the crankshaft is, in fact, adding weight to it will probably make the trouble worse. No couples of any kind may be permitted to develop within the crankshaft; every unbalanced effect must be compensated, and that not somewhere else in the shaft, but immediately in the plane of rotation of the part causing this unbalanced effect. This holds also in the aircraft end. If the engines be made so that they do not vibrate when run at 2000 r.p.m,, there will be wiped out nine-tenths of the other troubles, such as the breaking of pipe connections, of the wiring on the plane itself, and so forth, which all goes back to vibration of these parts.

On the other hand, H. M. Crane (Wright Aeroplane Co.), with respect to the question of vibration, called attention to the fact that the conditions in an aviation motor are different from those in an automobile motor. There you have to cover every speed up to 2000 or 3000, or even higher, revolutions per minute, while an aviation motor has mainly to run at full power at a certain fixed speed. Hence the eight can meet in an aeroplane the conditions for which a six or twelve cylinder engine is required in a motor car.

William R. McCulla (Packard Motor Car Co.) in describing his trip to Europe during the present war said that in Europe the lowest power with which they want to go up is 250 or 300 h.p. They had one motor of 600 h.p. which had been built in advance for a warplane, but this motor was put in a very fast motorboat for discovering submarines. Then they went to the geared-down motor (such as the Sunbeam) and had no trouble with gear reduction. These large motors use successfully four-bladed 14 ft. propellers. The specifications of the British Government now call for a disconnecting test of propellers to make sure that if the propeller becomes loose in the air or is shot away it will not smash the motor. As to trouble with magnetos, the speaker ascribed it to general lack of thoroughness in design and construction. He saw an aeroplane motor taken down to be overhauled. The motor was considered to be first-class, and still the closest any one of its pistons came to another was within 1¼ oz., that is, no two pistons were of the same weight. It hardly can be expected that any magneto could stand that.

Several of the speakers, especially those who have been in Europe, expressed dissatisfaction with rotary motors. Statements were made that the use of the Gnome motor, which was so popular in French aviation at the beginning of the war, has been now practically abandoned. (*Abstract of a stenographic report of the meeting of the Executive Committee of the National Advisory Committee for Aeronautics held at the Smithsonian Institution,* June 8, 1916, 58 typewritten pages.)

Dies

CAST-IRON DROP-FORGE DIES, A. R. Braden

Description of a method of making cast-iron drop-forge dies which has proved successful on a large variety of shoe-machine forgings in the Beverly factory of the United Shoe Machinery Co.

The possibility of using cast-iron dies instead of steel dies not only opens an opportunity to effect a large saving in the cost of new dies, but eliminates the necessity which exists on orders of between five and ten thousand pieces of repairing the steel dies, and often of planing off the old impressions and "sinking" new ones, a costly operation, and one which, in addition, delays the work of forging. Also, a common requirement is the changing over of steel dies to agree with a change in design of the forging, which is nearly as expensive as making new dies.

The method of making cast-iron dies is said to have been

perfected now to the highest point. The most important part of this process appears to be the production of the patterns. The original pattern proved to be defective and several improvements had to be made. A pattern was originated that made it possible to cast the die block and the shank with both draft and dowel holes, doing away entirely with machine work. To accomplish this the pattern for the shank was made in three parts—a wide rectangular centerpiece and two smaller strips, on each of which were cut the draft and dowel holes. Then, when in molding the pattern was ready to be drawn from the sand, the pins connecting the small pieces to the centerpiece were removed and the main part of the tongue drawn, making it possible to draw the small strips.

It was found that the correctness of the pattern was spoiled by the warping of the wood frames. This trouble was overcome by securing a casting of the pattern and using the latter as a model for molding the first die and for filing for future use. Further, an aluminum block pattern was provided to replace the old wooden one, thus giving a completely indestructible die pattern, with the exception of the pattern for the tongue, which it has not as yet been necessary to replace by metal.

The latest improvement is a pattern made entirely of plaster. A special frame similar in shape to the old wooden one is made of cast iron, and is adjustable by means of pegs and dowel holes to any one of the eight standard die sizes. This frame is placed flat on a surface plate, the wood model of the forging being held in the proper position relative to the frame by means of four clamps that bear on the parting line. The patterns for the break-down, anvil, sprue and cut-off are sawed out of wood and placed in their proper positions inside the frame. The plaster is then run into the frame and allowed to set. When hard, the frame is removed together with the model and patterns, leaving a complete plaster impression ready for molding.

In addition to discarding the stock of expensive wooden frames which had to be kept, a great deal of time is saved in that the break-downs, anvils, sprues and cut-offs can be cast with the impression of the forging by simply cutting out the necessary patterns from waste stock on a band saw. These plaster patterns made with the adjustable frame may be filed away without danger of warping. If they break they can be replaced in an hour's time.

The maximum time required to turn out cast-iron dies ready for the hammer is four days. (The average time for steel dies is from one to four weeks.) On one order a pair of cast-iron dies produced 5000 forgings. This record will not hold for all cast-iron dies, but in many cases their life nearly equals the life of steel dies.

Concerning trimming dies, it is stated that actual trials have proved them to be as successful in their line of work as the drop-forged dies are in theirs. Excellent results have been obtained both in hot- and cold-trimming work; for instance, one die, ground once, and one punch trimmed a thousand forgings through a flash fully 3/16 in. thick. (*American Machinist,* vol. 45, no. 15, p. 621, October 12, 1916, 5 pp., 22 figs. *d.*)

Engineering Materials

The Failure of Brass.—2. The Effect of Corrosion on the Ductility and Strength of Brass, Paul D. Merica.

Results of an investigation made on a homogeneous alpha brass have shown that the electrolytic solution potential of this material is increased by the application of a tensile stress. This increase, as measured, amounts to approximately 0.1 millivolt for a stress of 10,000 lb. per sq. in.

Using this fact as a basis, an explanation can be given of the decrease in strength and ductility of brasses when corroded while under stress. Over a roughened surface of a bar under tensile stress this stress will vary in value, being greatest at the bottom of furrows and depressions and least, almost zero indeed, at the tops of the ridges. The EMF will therefore, other things being equal, be greater; i. e., more electropositive, at the bottom of these furrows than elsewhere; corrosion will set in here most rapidly forming a crack, which will grow narrower and sharper, its rate of growth being greater the sharper it is. In time the cross-section of such a bar is so reduced by these cracks that fracture occurs, the brass failing apparently at a stress value less than the ultimate strength, and exhibiting only light elongation (ductility).

This explanation is borne out by the examination of a number of brass failures, which have occurred under such conditions. (*Bureau of Standards* Technologic Paper No. 83, advance abstract.)

The Constitution and Microstructure of Porcelain, A. A. Klein

A petrographic microscopical study of porcelains prepared in the laboratory of the Bureau of Standards and of commercial porcelain as well as of various combinations of the raw materials which enter into porcelain, has led to results which are interesting and important both scientifically and technically.

Bodies and mixtures of the following types were examined: kaolin, feldspar-kaolin, feldspar-quartz and feldspar-clay-quartz. These were burned to various known temperatures. The commercial bodies investigated represented the practices of the following countries: United States, England, Germany, France, Austria, Denmark and Japan. The end in view was to obtain data concerning the changes involved by burning porcelain at various temperatures, and it was found possible to correlate to a certain degree the constitution and microstructure with the burning temperature of bodies whose composition lay within the limits of whiteware and hard fired porcelains.

The result of this investigation leads to the following conclusions: Kaolin appears homogenous microscopically when heated up to 1200°. At about this temperature a trace of dissociation occurs. As the temperature is raised above 1200° the dissociation increases very slowly at first, then at an increasing rate until at 1400° it seems to be complete. The products of dissociation are silica and aluminum silicate. The latter compound has been identified as an amorphous phase of sillimanite from the following facts: It shows no crystalline form, has an index of refraction approximately above 1.60, and by heating at a higher temperature (about 1450°) it inverts to minute needle crystallites corresponding to sillimanite in all determinable optical properties.

Up to 1340° in mixtures of quartz and feldspar, the quartz dissolved to only a small extent in the feldspar glass. At 1460° the quartz practically completely dissolved in specimens having as high a quartz content as fifty per cent quartz to fifty per cent feldspar.

At 1340°, in specimens containing kaolin and feldspar, the kaolin dissociates entirely. The amount of crystallized and amorphous sillimanite increases with an increased content of kaolin at least to a concentration of fifty per cent kaolin to fifty per cent feldspar.

At 1460° apparently ten per cent kaolin is entirely soluble in the feldspar glass. With higher concentrations of kaolin the amount of crystallized sillimanite increases. The needle crystals are well developed and comparatively large.

At 1310° in quartz-clay-feldspar bodies, the feldspar is present as a glass; the clay shows almost complete dissociation, with the formation of amorphous sillimanite mainly and but little crystallized sillimanite, while the quartz is undissolved and the grains may still be of considerable size, up to 0.2 mm. or more, depending upon the fineness of grinding.

By burning these bodies at 1380°-1400°, the feldspar glass dissolves considerable quartz, there being only a comparatively small amount of residual quartz remaining. The quartz grains are much rounded and etched, and they seldom show a length over 0.06 mm. The clay is dissociated with the formation of crystallized sillimanite, although an extremely small amount of amorphous sillimanite may be present.

The changes involved by burning commercial bodies are identical with those of laboratory-prepared bodies. Commercial ware ranges from a low-burned porous whiteware in which, except for the dehydration of the clay, only the feldspar is changed, to very-high-fired porcelain which consists of glass, sillimanite crystallites and more or less of residual quartz. The quartz grains observed in the whiteware and in the low-fired vitreous ware are large and angular, showing a size of .2 mm. or more, whereas in the hard porcelain, due to solution, the quartz grains are rounded and etched, and seldom exceed .05 mm. in length.

The constitution and the microstructure of porcelain depend upon the temperature of burning and change as this temperature changes. This has served as a basis for the estimation of the probable burning temperatures of the commercial bodies, a fact which was accomplished with success, the error involved being within twenty-five degrees. It appears that the time-of-burning factor is by no means as important as that of the burning temperature in determining the constitution and microstructure of the ware.

No cristobalite or tridymite has been definitely observed in any of the laboratory or commercial bodies examined. It appears that the quartz dissolves in the feldspar glass more readily than it inverts to the other modifications of silica.

In conclusion it may be stated that the petrographic microscopic study of porcelain led to interesting and, it is to be hoped, important technical results. It has placed the chemical and physical processes involved in the formation of porcelain on a more quantitative thermal basis. Furthermore it has offered a means of estimating the burning temperature of a ware from the examination of a fragment much too small in size to be satisfactory for even a chemical analysis. (*Bureau of Standards*, Technologic Paper, No. 80, advance abstract.)

Some Aspects of the Testing of Refractories, A. V. Bleininger

Data on the behavior under various conditions of clay, silica, magnesite, aluminous, carbon and other refractories. In particular clay refractories have been investigated with respect to porosity, and the diagram Fig. 1 has been obtained showing the behavior of one open and four dense burning clays. This diagram represents five well-known European fireclays imported to this country in considerable quantities.

With increasing temperature the viscosity of refractories decreases, and this softening is the greater the larger the amount of fluxes present. It had been suggested, therefore, that the deformation at certain temperatures and under given load be used as a criterion of the refractoriness of firebricks. From the data recently obtained by the Bureau of Standards (Technologic paper, No. 7), it follows that the softening of the bricks becomes clearly manifest at 1350 deg. cent., which seems a suitable temperature for this test. The load to be supplied should not be greater than 40 lb. per sq. in., and not less than 25 lb. The relation between the deformation temperature T and the load W in pounds per square inch is expressed by Mellor's equation

$$T = Ce^{-KW}$$

where $C =$ deformation temperature of specimen without load; $K =$ a constant the numerical value of which depends upon the particular clay, and $e =$ exponential constant.

It was found that the more silicious the clay the less the difference between the deformation temperatures with and without load. On the other hand, the more the composition of

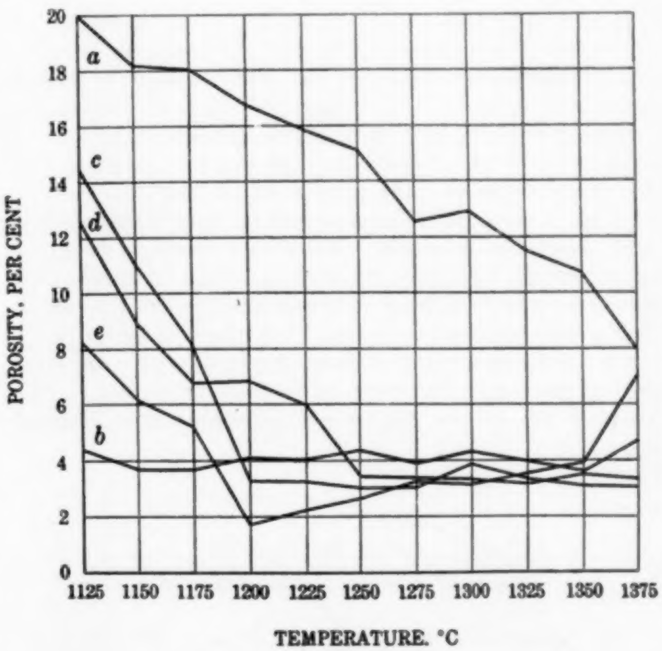


FIG. 1 DIAGRAM SHOWING BEHAVIOR OF ONE OPEN AND FOUR DENSE BURNING CLAYS

the material approaches that of the pure clay substances the greater is the difference between the deformation temperatures with and without load. It is possible, however, to produce high-clay firebrick showing excellent resistance to load conditions by using a mixture containing as high a percentage as possible of calcined No. 1 fireclay and a very refractory bond clay. Such bricks have been made under the direction of the writer and were found to possess an exceedingly small contraction with a load of 50 lb. per sq. in. and at temperatures of 1350 to 1400 deg. cent. (*Proceedings of the Engineers' Society of Western Pennsylvania*, vol. 32, no. 7, p. 612, October, 1916, 34 pp., 14 figs., *e A*.)

Stress Produced by Burning-In Manganese-Bronze, Paul D. Merica and C. P. Karr

An investigation of the initial stresses produced by the burning-in of manganese-bronze made in connection with the failure of a number of manganese-bronze valve castings used in the Catskill aqueduct.

In that work experience has shown that large castings of this material after some months of service have developed fissures through which leakage takes place under only a few pounds of pressure. Nearly all these cracks appear to be close to or in a repair made by the method of burning-in. It was assumed that, after the burning-in, stresses remained in the casting particularly severe near or within the burning-in area, and that these stresses were responsible for the subsequent failure at these points.

An experimental investigation was carried out to determine the presence and magnitude of these stresses. It was found that actually after the burning-in there result stresses greater than the elastic limit of the material and the material yields thenceforth, the stress following (with probably some time lag) the elastic limit of the material, so that the stress as measured one or two days after burning-in represents the true elastic limit of the material.

The experiments have indicated how readily severe stresses may be introduced into a casting by the burning-in or welding of a strained area or part of it. These stresses may be modified in complicated shapes by the added influence of distortion. For instance, in the spherical shell or dome-shaped valve casting of the New York Board of Water Supply burning-in would tend to flatten the shell and in so doing partly relieve these stresses. The authors believe that even in these castings, however, local stresses equal to the true elastic limit must have been produced. Hence such castings should be either preheated carefully for welding so that all parts of the casting cool down together from a dull red heat or the casting should be subsequently annealed. Experience indicates that a low temperature anneal is sufficient for this purpose, say from 400 to 500 deg. cent. from for one to two hours. (*The Foundry*, vol. 44, no. 290, page 431, October 1916, 3 pp., 4 figs. *ed.*)

Fuels

Stationary Boilers Fired by Pulverized Coal on the Missouri, Kansas & Texas Railroad

The equipment for pulverizing and drying fuel is contained in a separate building, the coal being dumped from the cars directly into a concrete track-hopper of 50 tons capacity adjoining the building. The plant is designed to handle either mine run or slack coal, and immediately below the track-hopper is placed a set of Jeffrey double spike-tooth rolls which will reduce lumps up to 12 in. by 18 in. to 5 in. cubes or less in one operation.

The equipment throughout the pulverizer plant is operated by electric motors. The capacity of the pulverizer plant is 180 tons per day of 24 hours.

The boilers in the power house are arranged in pairs, and for pulverized fuel are provided with a Dutch-oven furnace built on the front of the boiler setting. Each pair of boilers is provided with a blower driven by a 10 h.p. constant-speed direct-current motor, a blast pipe from this blower entering the rear end of an induction tube passing through the wall of each furnace. The fuel from the feeders is led by gravity through a pipe entering the top of the induction tube near the front of the furnace. The action of the high velocity jet from the blast pipe induces a large volume of air at lower velocity through the induction tube; the fuel is caught by this current, is thoroughly mixed and enters the furnace at a low velocity, burning with a lazy flame, which practically fills the combustion chamber. The boilers were formerly provided with 3-pass horizontal baffles. In the pulverized fuel fire boilers these baffles are being replaced by a vertical 3-pass arrangement from which excellent results have been obtained.

Various tests have been made with the different fuels mentioned, and all of them were burned with entire success. An effective distribution of the heat throughout the heating surface of the boiler was obtained and the stack temperatures were low. No deposit of ash that could not readily be dislodged with an ordinary air blast settled anywhere in the boiler.

With Texas lignite and a boiler output of 110 per cent of rated capacity, an equivalent evaporation of 8.81 lb. of water per pound of combustible was obtained. The coal, as fired, had a heating value of 11,250 B.t.u. and contained 7 per cent moisture, the dryer not being arranged to handle this class of fuel regularly. At about 92 per cent of rated capacity an equivalent evaporation of 10.9 lb. of water per lb. of combustible was obtained with Mineral slack (Cherokee County, Kansas), the fuel as fired containing 1 per cent moisture. Including the cost of pulverizing, 35 cents per ton, the cost of this coal delivered to the bin was $1.795 per ton. The cost of evaporating 1000 lb. of water was 11.6 cents, while with natural gas, of heating value about 940 B.t.u. per cu. ft. and costing 12.5 cents per 1000 cu. ft., the cost of evaporating 1000 lb. of water was 16 cents.

The normal coal feed is arranged to develop about the rated capacity of the boiler. At maximum feed, however, the boilers may be forced to 142 per cent of rated capacity. No difficulty has been experienced from abnormal furnace temperatures which would tend to destroy the furnace walls. Even under forced conditions the furnace temperature does not exceed 2350 deg. fahr., and under normal conditions it is about 2100 deg. fahr. (*Railway Age Gazette*, vol. 61, no. 13, page 549, September 29, 1916, 3 pp., 2 figs. *de.*)

Furnaces

New Annealing Furnace

At the plant of the Remington Arms Company, Eddystone, Pa., there are now in operation two annealing furnaces employing the surface combustion principle and giving a neutral or reducing atmosphere which makes it possible to treat the forgings without packing or otherwise protecting them against possible oxidation.

The furnaces were provided for annealing rifle parts immediately after forging. They are of the car-bottom type, 20 ft. long, 12 ft. wide and 9 ft. high. The charge to each furnace varies from 20,000 lb. to 40,000 lb., depending upon the parts handled. A mixture of water and coal gas is used, averaging 580 B.t.u. per cu. ft. The gas is delivered and metered under a pressure of 25 lb.

During the heating-up period, each furnace consumes about 10,000 cu. ft. of gas per hour. When the temperature has been reached this is dropped to about 5000 cu. ft. per hour. For a maximum weight charge, approximately 72,000 cu. ft. of gas is used by each furnace. Two charges per furnace can be secured in a 24-hr. day.

The annealing temperature is 1550 deg. fahr.

The furnaces are of the heavy-rail buck-stave type, with red brick outside. The firebrick lining is backed by cork-brick insulation. To prevent in-leakage of cold air, giving an oxidizing atmosphere and lowering the furnace efficiency, a furnace back pressure is carried, the flue openings being small enough to cause this condition.

Both furnaces are controlled from a central point by a

single valve, which regulates the pressure supplied. It takes only little of a man's time to hold the furnaces to the exact temperature called for. To maintain a proper reducing atmosphere, the mixture is adjusted to give a flue-gas reading of about 1.2 per cent carbon monoxide.

The article is illustrated by a section of the furnace showing the refractory material kept at incandescence by the high-pressure gas burners. (*The Iron Age*, vol. 98, no. 12, p. 636, September 21, 1916, 2 pp., 2 figs. *d.*)

Handling Materials

A Large Reinforced-Concrete Coaling Plant

Description of the new station for the Duluth, Missabe & Northern Railroad, at Proctor, Minn., having a storage capacity of 1000 tons of coal. Of interest because it represents recent developments in equipment for handling coal and sand.

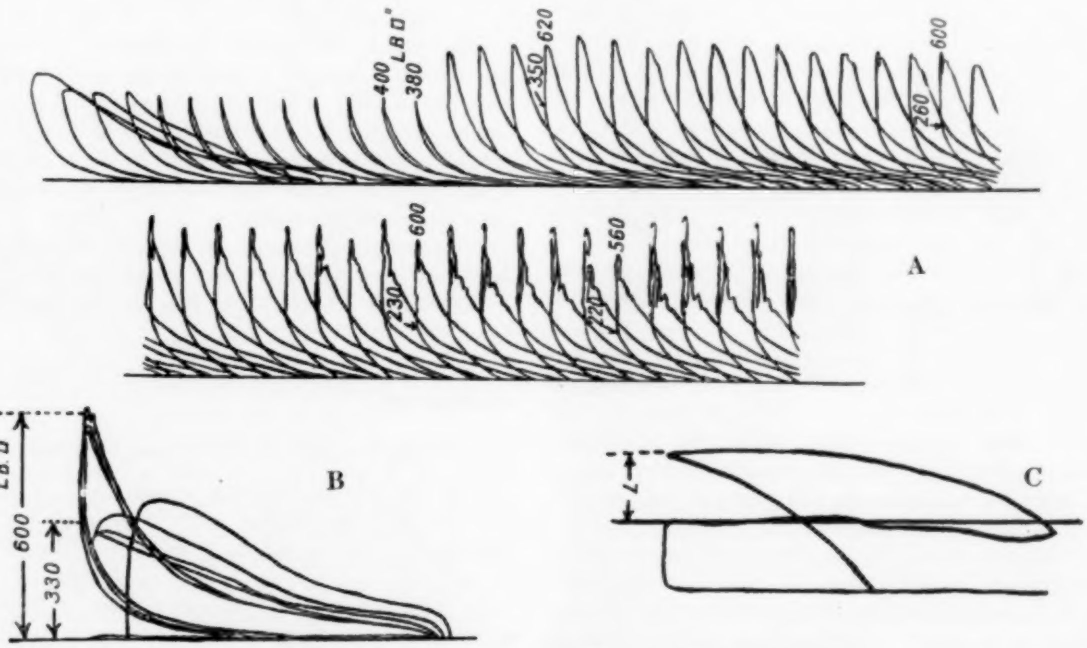


Fig. 2 Starting Diagrams with Reduced Compression

The design of the superstructure of the station structure is simple. The bins are supported on two rows of concrete columns along the two sides of the building, six 2 ft. by 2 ft. 6 in. columns in each row. Transverse girders of the same width as the columns span between opposite sides of the building over each pair of columns and support the floor of the bin. The sides of the bins are 7 in. thick and span horizontally between pilasters which are 18 in. wide and project 11 in. into the bin. These pilasters are located directly over each column along the two sides of the building and at a spacing of about 10 ft. center to center at the two ends. They distribute the lateral pressure of the coal to the top and bottom of the bin, the pressure being absorbed at the bottom by the floor system and at the top by a horizontal girder; the latter is continuous on all four sides and is braced at each corner by a diagonal tie or horizontal knee-brace which connects the nearest pilasters in adjoining walls.

The coal delivered to the track hopper in bottom-dump cars is fed by a Schraeder measuring feeder into the elevating bucket. This feeder has a capacity of 2½ tons, and is actuated by the ascent and descent of the elevating bucket, being arranged in such a manner that 2½ tons of coal are discharged into the bucket each time the latter passes by the feeder in its descent.

The coal is retained in the bucket by means of an apron at the bottom. The apron is equipped with a 6-in. roller traveling on a continuous steel guide from the bottom of the pit to the bucket discharge point. This insures the retention of the coal except when the roller guide permits the apron to open up at the top of the tower to discharge the coal into the bin.

The operation of the bucket when handling sand is exactly the same. The sides of the track hopper have a slope of 50 deg. to insure the ready flow of the wet sand. Deflectors are provided in the chute at the top of the shaft to deflect the sand into the sand chute as well as to control the flow of coal into either one of the bins.

A brief description of the sand-drying plant is given. It is of the Beamer steam type, and is so designed that the steam pipes themselves act as retaining walls for the green sand, permitting the moisture to escape immediately into the atmosphere. The spaces between the coils are such that they readily hold the green sand but permit dry sand to slip through and fall onto a gravity sand screen which removes all foreign matter and particles of sand of too large a size. From the screen the sand passes into a hopper of an automatic air drum, from which it is blown by compressed air into the dry sand storage pocket. (*Railway Age Gazette*, vol. 61, no. 13, p. 542, September 29, 1916, 3 pp., 6 figs., *d.*)

Internal Combustion Engineering

Diesel Engines with Low Compression, Prof. W. H. Watkinson

Abstract of a paper presented to the Newcastle meeting of the British Association, September, 1916. In order that the temperature of the air in Diesel engines may be raised during

compression to the ignition temperature of the oil, the compression pressure is about 460 to 500 lb. per sq. in., and it has hitherto been believed that this high compression pressure was necessary to effect self-ignition of the oil sprayed into the compressed air.

While during the normal working of these engines the compression pressure is approximately the maximum pressure of the cycle during the starting period explosions occur within the engine cylinder and the pressure attained during these explosions may amount to 800 lb. per sq. in. or more. Because of these and other pressures which are liable to be developed under certain abnormal conditions, it is necessary to make various principal parts of the engine much stronger than would be necessary for the normal maximum working pressure. The author has found, however, that it is possible in several different ways to obtain ignition temperatures during compression without the use of high compression pressures.

Fig. 2A shows a number of continuous diagrams from the engine after these additions have been made to it. In all these diagrams the compression pressure is very much lower than the minimum pressure hitherto believed to be necessary for self-ignition. In the second row of these diagrams the ignitions are shown to be taking place quite regularly with a compression pressure of 220 lb. per sq. in. Fig. B shows a diagram for the starting air and explosion due to self-ignition with a compression pressure of 330 lb. and a maximum explosion pressure of 600 lb. per sq. in. and different atmospheric pressure, these diagrams being the first to be taken on a certain morning when the engine was first started from all cold.

Fig. C shows a light spring diagram and indicates one way by which it has been possible to obtain ignition temperatures without a high compression pressure.

The equation of the compression curve shows that the temperature at the end of compression in any given case depends on the ratio of compression and not on the magnitude of the pressure at the end of compression. Further, the experiments of the late Dr. Joule indicate that the temperature is not sensibly reduced by wire-drawing, and therefore the temperature at the beginning of compression is independent of the pressure of the air, while the temperature of the air at the end of compression is independent of the compression pressure. Hence, it should be as easy to obtain ignition temperature by compression to two atmospheres as it is to obtain it in the ordinary way by compression to 34 atmospheres. (The author has not yet, however, made any experiments with such low compression pressures.) To avoid the very high pressures obtained during the starting of the engine it is only necessary to throw the mechanism operating the air-admission valve out of action, and then the spring of the valve spindle will automatically control the wire-drawing of the air admitted to the cylinder and the maximum explosion pressure during the starting of the engine will then be limited to about the normal compression pressure instead of its being 800 lb. per sq. in. or more. (*The Engineer,* vol. 122, no. 3169, p. 266, September 22, 1916, 2 pp., 7 figs., *d e.*)

Leather Articles

Manufacture of Pump Leathers

Description of the production of pump leathers at the plant of W. & B. Douglas Co., Middletown, Conn. Leather cups are produced by a process analogous to the drawing-up process of working brass and other sheet metal which imposes upon the material a particular set of conditions. As numerous kinds of leather articles, such as cup leathers, valve leathers, head packing, coupling packing rings, etc., have to be produced, the elementary stages are usually identical throughout the complete list of shapes. The starting point is shaving the leather to the desired thickness, after which the work is cut out to the desired size and shape by special punches and dies. These dies are made in hundreds of sizes and in scores of patterns.

The forming operation is accomplished in the pneumatic press. In this machine, operated by air under 60 lb. pressure, the work is pushed down to a steam-heated die. The actual die surface is about 1 ft. deep and each cup leather is pushed and formed up and punches the one below it down through the bottom of the die. The die is heated by steam. If the die or sleeve in which the work is formed gets too hot, the leather is likely to crack, so cold water is turned on, when the operator can tell by touch that the die has become too highly heated. It is, however, just as important that the die should not get too cold, for if it does the cup leather will wrinkle in the drawing-up process.

This drawing-up of cup leathers is an operation requiring considerable skill and judgment on the part of the workman. Certain conditions obtained are quite similar to the drawing-up of brass. A slight wrinkle in the form of the die leathers actually produces a shallow channel in the outer surface of the cup. While the cup material is flexible enough to take care of a certain degree of irregularity, it is not desirable that a depression or crease extending across the face should result from this forming process.

The article is illustrated by views of the pump leather department, dies, machinery and finished product. (*American Machinist,* vol. 45, no. 15, p. 631, October 12, 1916, 3 pp., 5 figs. *d.*)

Machine Shop

Parallel-Depth Bevel Gears, William C. Glass

Since the particular shape of the teeth of bevel gears is non-essential, provided the teeth in the mating gear are conjugates in so far as action is concerned, the ideal condition would be to have the teeth of such a form that exactly the same procedure and kind of cutter would be required to produce both. Still further advantage could be derived from producing such a form of tooth with rotary cutters on an automatic machine that can be set up by an ordinary machinist. This has been accomplished in a simple manner by a method by which hundreds of gears have been cut. So far they have been cut on a universal gear cutter requiring two settings to complete the gear, but the author claims that it would not be difficult to make the operation fully automatic.

The process admits of two general designs, (1) the stub-tooth form used preferably in new designs on account of its greater strength; and (2) the standard-depth form for gears to mesh with others cut by one of the generating processes.

It is necessary to have for each gear a gage for setting the gear cutter and a thickness gage equal to 1.157 ÷ diametral pitch for obtaining the proper depth of cut. It is also well to have a testing fixture for trying the gears in pairs.

Fig. 3A gives the particular data required in this process. X represents a bevel gear and Y its setting gage. For the stub-tooth form is used a standard involute spur-gear cutter, and for the standard-depth form an involute bevel-gear cutter. The writer gives the following formulae and data:

Known W = center and cut angles, diametral pitch (in the stub-tooth form W is the center, cut and face angles.

In the standard-depth form W is the center and cut angles, while the face angle is formed by a line Z, Fig. A, from the corner of the gear to the apex of the pitch cone as in the regular bevel gear)

N = number of teeth

T = thickness of cutter at a depth of 1.157 ÷ diametral pitch

Required $2C$ = diameter of setting gage

V = set-over angle

D = diameter from which to choose cutter

$$C = T/(2\sin 90/N)$$

$$R = C/\sin W$$

$$D = 2R \tan W$$

$$\sin V = T/2R$$

The cutter is set central in relation to and in line with the spindle and brought to the gage, as shown in Fig. B. The cutter is drawn back (see Fig. C) and replaced by a height gage that is centered over the swiveling stud in the gear cutter. A thickness gage equal to 1.157 ÷ diametral pitch in thickness = B is placed between the point of the height gage and the gear gage. The slide is then tipped up to the cut angle and moved out until the point of the height gage is brought to the corner of the gage Y, as shown in Fig. D. The gear gage Y is then replaced by the gear blank X. The slide is next turned about the swiveling stud the amount of the set-over angle V (cp. Fig. E) and a cut taken around the gear. The slide is then set over the opposite side of the center line the amount of the set-over angle V and a final cut taken around the gear.

This process has been developed by Frank C. Stevens. (*American Machinist*, vol. 45, no. 15, p. 633, October 12, 1916, 2 pp., 6 figs. *d.*)

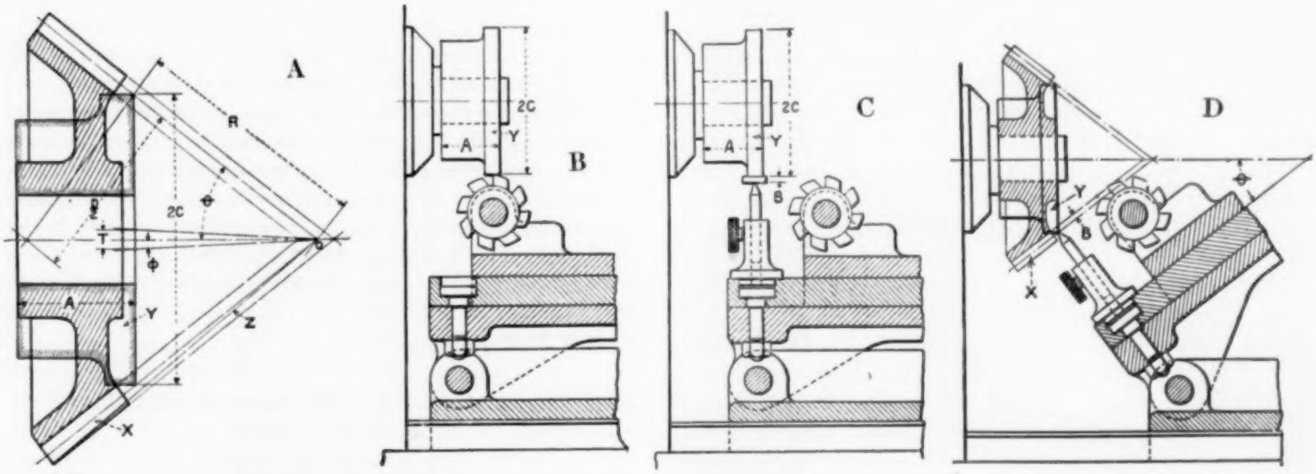


Fig. 3, A, B, C, D Layout and Method of Cutting Parallel-Depth Bevel Gears

Measuring Apparatus

Liquid Measuring Pumps, F. J. Schlink

The importance of the measuring pump is principally due to the large quantities of gasoline sold as fuel for motor cars through its various forms. About 27 firms are now engaged in the manufacture of the various measuring pumps and liquid dispensing systems.

The main types of measuring pumps are the piston pump, which is in principle the usual plunger pump with stops that act to define accurately the limits of the piston stroke and consequently the volume generated by the piston on each cycle; and the meter pumps in which the measurement is performed by passing the liquid through a meter, commonly of the nutating-piston type, the discharge of liquid through the meter being produced either by displacement of the oil over water, by pneumatic pressure or by mechanical pumping.

A third type of measuring system is founded upon the principle of overfilling a measuring chamber and then removing the excess by abstraction to a definite level. In a modification of this type the measurement is obtained by direct reading of the height of the liquid column on a graduated scale at the beginning and end of the withdrawal of the liquid from a tank or cylinder.

A portable apparatus is also in use comprising a small storage tank and a measuring pump. The precision of such devices is usually higher than that of most stationary tanks, as the suction lift can be kept a minimum and the danger of vaporization and leakage below the piston is much reduced.

In the testing and inspection of measuring pumps it is essential to determine whether the installation is free from inward leaks of air and outward leaks of gasoline.

The principal causes of short delivery of pumps of the piston type are leakage of foot valves and formation of vapor or air spaces under the piston. It appears that a total vertical suction lift greater than 7 ft. may be excessive with the ordinary commercial (not "blended" or "casing-head") gasoline. "Casing-head" or "blended" gasoline should not be lifted any appreciable vertical distance on the suction side in pumps in which the pistons and cylinder form the measuring elements, on account of the vaporization difficulty before-mentioned.

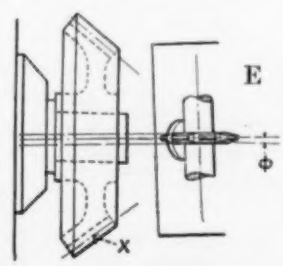
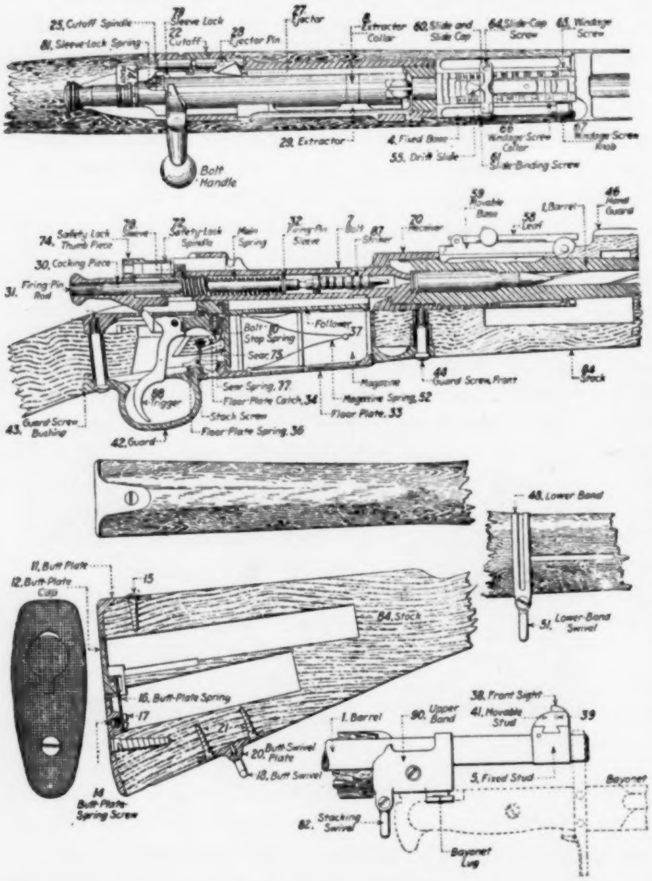


Fig. 3, E Final Cut

The writer discusses several other sources of error, among which is the possibility of short deliveries consequent upon operating the piston at less than full stroke. It is noteworthy that nearly all of the defects of construction and installation



Barrel:
- 1 Barrel
- 2 Base pin
- 3 Base spline
- 4 Fixed base
- 5 Fixed stud
- 6 Stud pin

Bolt:
- 7 Bolt
- 8 Extractor collar

Bolt Stop:
- 9 Bolt-stop pin
- 10 Bolt-stop spring

Butt Plate:
- 11 Butt plate
- 12 Butt-plate cap
- 13 Butt-plate pin
- 14 Butt-plate screw, large
- 15 Butt-plate screw, small
- 16 Butt-plate spring
- 17 Butt-plate screw

Butt Swivel:
- 18 Butt swivel
- 19 Butt-swivel pin
- 20 Butt-swivel plate
- 21 Butt-swivel screws (2)

Cutoff:
- 22 Cutoff
- 23 Cutoff plunger
- 24 Cutoff screw
- 25 Cutoff spindle
- 26 Cutoff spring
- 27 Ejector
- 28 Ejector pin
- 29 Extractor

Firing Pin:
- 30 Cocking piece
- 31 Firing-pin rod
- 32 Firing-pin sleeve
- 33 Floor plate
- 34 Floor-plate catch
- 35 Floor-plate pin
- 36 Floor-plate spring
- 37 Follower

Front Sight:
- 38 Front sight
- 39 Front-sight pin
- 40 Front-sight screw
- 41 Movable stud
- 42 Guard
- 43 Guard-screw bushing
- 44 Guard screw, front
- 45 Guard screw, rear
- 46 Hand guard
- 47 Hand-guard clips (2)
- 48 Lower band
- 49 Lower-band screw
- 50 Lower-band spring
- 51 Lower-band swivel
- 52 Magazine spring
- 53 Mainspring

Rear Sight:
- 54 Base spring
- 55 Drift slide, 0.05 peep
- 56 Drift-slide pin
- 57 Joint pin
- 58 Leaf
- 59 Movable base
- 60 Slide

Rear Sight (Continued):
- 61 Slide binding screw
- 62 Slide cap
- 63 Slide-cap pin
- 64 Slide-cap screw
- 65 Windage screw
- 66 Windage-screw collar
- 67 Windage-screw knob
- 68 Windage-screw pin
- 69 Windage-screw spring
- 70 Receiver

Safety Lock:
- 71 Safety-lock plunger
- 72 Safety-lock spindle
- 73 Safety-lock spring
- 74 Safety-lock thumb piece
- 75 Sear
- 76 Sear pin
- 77 Sear spring

Sleeve:
- 78 Sleeve
- 79 Sleeve lock
- 80 Sleeve-lock pin
- 81 Sleeve-lock spring
- 82 Stacking swivel
- 83 Stacking-swivel screw
- 84 Stock
- 85 Stock screw
- 86 Stock-screw nut
- 87 Striker
- 88 Trigger
- 89 Trigger pin
- 90 Upper band
- 91 Upper-band screw

Fig. 4 Sections of Springfield Model 1903 Service Rifle

(leakage of air and liquid, retention of liquid by the hose, vapor formation consequent on excessive suction head, failure to complete the full stroke, and slippage of liquid past valves and piston) tend to produce errors in the one direction of undermeasurement. (*Abstract of paper read at the Annual Conference of Weights and Measures of the United States, May 23, 1916.*)

Munitions

United States Munitions. A Springfield Model 1903 Service Rifle. General Specifications and Barrel Operations

With this article begins a complete description of the manufacture of the Springfield rifle, showing each operation of each component part and illustrating the machines, tools, jigs, fixtures and production methods. The major part of the article, notwithstanding its high interest, is unsuitable for abstracting.

There are 93 component parts in this rifle. The names are listed under Fig. 4, which shows the important parts by numbers.

The steel used in the rifle is divided into seven classes. These are music wire and screw stock of commercial grade; three classes of steel made by the open-hearth or crucible process and two classes of steel made by either open-hearth or Bessemer process. The proportions of carbon, manganese and silicon may be varied, but the maximum limits given for manganese, sulphur and phosphorus must not be exceeded. No nickel or other alloys shall be used in any of the grades. Data are given on an annealing of the forgings used in the manufacture of the rifle. (*American Machinist*, vol. 45, no. 15, p. 635, October 12, 1916, 12 p., 69 figs., *d A*.)

Teaching the Manufacture of United States Munitions, Howard E. Coffin

Introduction to a series of articles on the manufacture of munitions for the United States Government. The author emphasizes anew the need of organizing and educating the industries of the United States in the manufacture of munitions. He points out the vital need for a text-book dealing with this work.

The experience on orders for foreign governments has taught American manufacturers that the making of materials of modern warfare is a new art, in which we have had little or no previous experience and in which our workmen are unskilled.

There are in the United States vast resources in manufacturing and producing equipment, but they are unorganized and uneducated for the national service. European experience teaches, however, that it is upon organized industry that all plans of military defense must be based, and in case of trouble with any first class power from 80 and 90 per cent of our industrial activities would be centered upon the making of supplies for the Government.

Industrial preparedness is strictly in keeping with the natural tendencies and abilities of the American people. The necessary resources are present, but to make them available in time of emergency most careful methods of organization and education are essential.

The article proceeds to a discussion of the work of the Naval Consulting Board, in particular that of the Committee on Industrial Preparedness. The work accomplished by this Committee will in due time be turned over to the newly authorized Council of National Defense, which will carry forward the work of education and organization of our resources for national emergency service.

The writer expresses in strong terms his appreciation of the work done by the editor-in-chief and staff of the *American*

Machinist in this direction of education in the manufacture of munitions. (*American Machinist,* vol. 45, no. 15, p. 617, October 12, 1916, 1 p. *g.*)

Railroad Engineering

LOCOMOTIVE PROBLEMS THAT DEMAND SOLUTION, George M. Basford

Discussion of a few of the more important phases of design and operation which are greatly in need of attention.

The author claims that very little positive information is available upon the circulation of water in the boiler.

Much attention is being devoted to grate design. Conditions requiring maximum power lead to the conclusion that air openings through the grates should be as large as the character of the coal used will permit. Thirty per cent is aimed at. A vital factor in the production of heat is the design of the ash pan, a difficult problem, as the speed of gases in a big fire-box working hard may be as high as 200 miles per hour. It is no easy matter to provide air openings in the ash pan sufficient to maintain their atmospheric pressure at maximum rate of power development.

To attain, with all fuels, the highest degree of heat intensity per unit of fire-box volume is a problem in which, according to the writer, important developments are almost ready to be announced.

Another big problem is that of burning the gases completely before they reach the flues. The tendency seems to be in the direction of larger fire-boxes, larger grates, larger combustion chambers, and new developments in the mixing of the burning gases by improvements in brick arches.

A promising field is that of front air-draft appliances, such as pump action necessary for draft with minimum back-pressure load on the cylinders. The author asks why a front-end construction that itself consumes 33 per cent of the draft produced should be perpetuated.

Improved valve motion and improvements in superheating are two fields where great progress has been made and still greater possibilities exist.

Of equal importance is the matter of feed-water heating. Successful feed-water heating will permit of modernizing existing boilers of outclassed locomotives to render them in many cases again available for service which has outgrown them. Locomotive boilers should be relieved of the duty of heating water; it should come to them hot, leaving only the evaporation to be effected in the boiler.

The matter of water purification is becoming more important every day.

The compounding principle is coming into its own. No locomotive improvement fills its natural field so well, when properly fitted into the general scheme of locomotive design.

Regarding the use of alloy steels, the author states: "If you could see confidential figures now in the desk of your speaker some of you would jump to the task of improving locomotive design with respect to lightening reciprocating and revolving parts of locomotives."

Best locomotive records reflecting up-to-date developments show a water rate of 14.6 lb. per i.h.p.-hr. What may be termed unimproved locomotives produced this unit on about 24 to 30 lb., and between these figures lie great possibilities, especially as the majority of locomotives are in or near the 24-lb. class.

(*Railway Age Gazette,* vol. 61, No. 13, p. 539, September 29, 1916, 3 pp., *g.*)

COMMERCIAL MOTOR VEHICLES FOR RAILWAY AND INDUSTRIAL PURPOSES

Description of the Tilling-Stevens gasoline-electric vehicles, particularly the type designated by the makers as TS-3, 40 h.p.

The wheel base is 13 ft. 6 in., with a wheel track of 5 ft. 6½ in. and an overall length of 23 ft. 9 in. The load, including body, is rated up to 4 tons 15 cwt.

The frame is of pressed steel throughout, braced by cross-members having large gussets formed solid with them. Each of the main side members is pressed from one solid steel plate and is long enough to take the longest type truck body. The engine is of the 4-cylinder enclosed vertical type, 4.75 in. bore and 5.5 in. stroke. Cylinders are cast in pairs with the inlet and exhaust valves (interchangeable) placed on the near side and operated by a single cam shaft. Oil is circulated by means of a gear pump situated in the oil sump formed in the bottom half of the crankcase. The connecting rods are provided with dippers which pick up the oil from the troughs and distribute it to the working parts of the engine. The lubrication is entirely automatic.

The radiator is of the plain tubular type with large water tanks, and the whole of the system is free from pockets in which steam or air might collect. The fan is driven by a Whittle belt.

Electric transmission consists of a generator driven directly by the engine through a flexible coupling, a series-wound electric motor direct coupled to the cardan shaft and the controller box. The generator is capable of an output of from 1 to 30 kw. at a speed varying from 350 to 1400 r.p.m. and voltage from 0 to 300, and has been designed with a falling characteristic so that any increase in demand for current when the engine is fully loaded is accompanied by a corresponding reduction in voltage. The output in kilowatts at any speed is proportional to the power exerted by the engine, but the volts and amperes may vary over a large range according to the gradient, speed or degree of acceleration required. The controller and speed regulator are carried in separate aluminum cases. The controller is of the tramway type with screw adjustment to the contact fingers. The speed regulator is of the multiple-contact type and operates by varying the resistance in the shunt field of the generator and by shunting the series field of the motor. On level roads and ordinary gradients the whole of the control is effected by a gas throttle pedal operated by the right foot of the driver. On stiff gradients the shunt resistance has to be employed to allow of increased engine speed.

The electric equipment cannot be burned out, as the maximum effort of the prime mover, namely, the engine, is limited. The drive from electric motor to back axle is by means of a propeller shaft fitted with universal joints at each end. The back axle is worm-driven, the worm being placed above the worm wheel. The steering is of the irreversible Ackermann type; it is fully described and illustrated in the article.

One of the advantages claimed for the gasoline-electric car is the elimination of gear changing. It has been calculated that the average number of gear changes in an omnibus in London public service amounts to 800 a day. The strains on transmission and chassis during starting are at least twice as great as with an indirect gasoline-electric drive, and may be considerably more than this, as illustrated in the diagram, Fig. 5, in which Curve I indicates the strains due to the starting up of a gear-driven omnibus of the latest type, and Curve 2 is due to an electric transmission of the same capacity. In the first case the starting is effected by three successive im-

pulses with intervals of no load due to the disengagement of the clutch between each change of speed, the maximum strains being limited by the condition of the clutch and the personal element of each driver. It must be further borne in mind that a tired driver may at any time let his clutch in with practically the effect of engaging a dog clutch, causing extremely heavy strains on the transmission and all parts of the vehicle, as indicated by the dotted lines on Curve 1.

In Curve 2 it will be seen that the same amount of energy applied to the road wheels by an indirect electric drive will not require half the maximum torque demanded in the case of clutch-and-gear transmission, as the impulse is continuous, increasing gradually with the excitation of the generator, and it is not in the power of the driver to increase this torque otherwise than gradually. (*The Railway Gazette*, vol. 25, no. 10, p. 255, September 8, 1916, 6 pp., 11 figs. *d.*)

Initial Strains in Steel Rails

Abstract of a report made by James E. Howard, engineer-physicist of the Interstate Commerce Commission, on the ex-

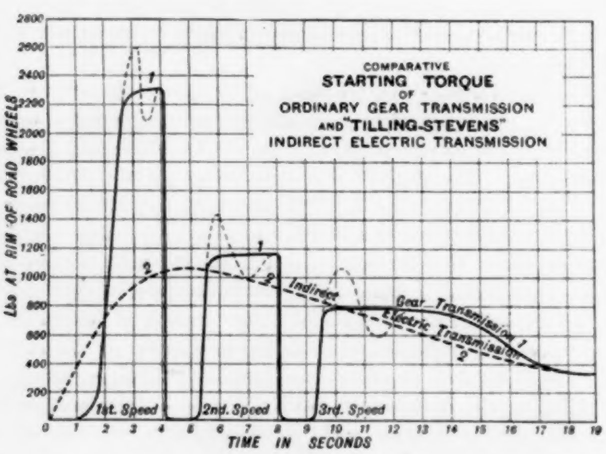


Fig. 5 Comparative Starting Torque of Gear and Electric Transmissions

amination of the rail the failure of which caused a derailment of a passenger train on the Western Maryland Railroad (Jan. 7, 1916).

According to the report, the investigation showed that the rail that caused the derailment failed by the head splitting, from lack of structural soundness of the steel.

The writer traces this latter to the state of the metal in the ingot that produces seaminess, and it is this seaminess, rather than segregation, that apparently constitutes the real danger.

As a mill question it is, therefore, important to remove the causes of this seaminess, and until this is done reliance must be placed on track inspection for the detection and removal of rails having split heads.

The report discusses further the effect of initial strains in the rail. Such initial strains, due to cooling during fabrication and to the cold-rolling action of the wheels on the running surface of the head, increase the total stresses of the rails when the wheels are in certain positions. These initial strains should, therefore, be taken into consideration in judging the strength and ability of the rails to endure the loads imposed upon them in the track.

The report discusses further the effect of initial strains in rails under normal conditions of cooling when the rate of cooling was accelerated and when it was retarded, and of the strains present in annealed sections. As to the effects of gagging, it is stated that the magnitudes of the initial strains in the gagged sections were found to be lower than those in the corresponding sections which cooled normally. In the head, the normal condition of a state of compression was reversed and initial strains of tension were introduced. The report insists upon a distinction between the permanent sets of tension or compression that are given the rail by the process of gagging, and the initial strains that result therefrom.

The effects of sudden heating have a bearing upon the strains momentarily introduced in rails when "wheel-burns" occur, as well as influence the strains in brake shoes and the rims and plates of wheels. (*The Iron Age*, vol. 98, no. 12, p. 654, September 21, 1916, 1 p. *e.*)

Refrigeration

The Testing of Thermal Insulators, H. C. Dickinson and M. S. VanDusen

Data of work done at the Bureau of Standards, communicated by H. C. Dickinson to the Annual Meeting of the American Society of Refrigerating Engineers, New York, December, 1915.

The writers point out that between the simple mathematical and physical problem of heat transfer through a homogeneous solid material, or even several such materials combined, and the practical engineering problem of heat transfer, there is a long step which neither the experimental physicist nor the engineer has generally been inclined to take. This led to two distinct groups of experimental investigations, one of which offers an immense quantity of data on the internal conductivity of many materials, while the other offers a large number of determinations of the apparent heat transmission of various simple and compound walls, often under ill-defined conditions of surface temperature. The writers give certain definitions which are of interest, since the terms defined are not always used in the same sense in technical literature.

Conductivity is equivalent to specific conductivity or internal conductivity (*i. e.*, the amount of heat passing per unit time through a unit area of the material when the temperature gradient is 1 deg. per unit thickness.

Gradient is the space rate at which temperature changes in passing through the material.

Conduction is the amount of heat per unit area which will pass in unit time between the surfaces of the wall when the temperature difference between them is 1 degree.

Transmission is the amount of heat which will pass (unit time, unit area) through a given layer of insulating material when the temperature difference between the medium (air, brine, etc.) on one side of it and that on the other side is 1 degree.

Thermal *resistance* is the reciprocal of conduction.

The paper discusses the computation of transmission of compound walls and analyzes the air-conduction problem. From this the writers pass to a description of the investigation of the apparent conduction of air spaces as part of the study of the problem of insulation. A description is given of the apparatus used which consists essentially of a pair of copper heater plates enclosing a uniform electric heating element and two water-cooled outside plates. The heat supplied is determined by measuring the electric energy delivered to the plate. When used for air-conduction measurements, bottomless boxes of soft wood or other suitable material are

made of various thicknesses to afford different widths of air space. They are inserted between the heater plate and the water-cooled plates just as a solid insulation sample would be.

Important variations of the apparent conduction through air spaces occur with change of width, although it has often been assumed that all air spaces have about the same conduction. Actually for very narrow spaces, that is, less than $\frac{3}{8}$ in., the *resistance* to the passage of heat increases almost in proportion to the thickness. Beyond this the resistance increases less rapidly, until it reaches a maximum above which a *greater* thickness offers *less* resistance to the passage of heat. It is plain that convection plays no appreciable part in the conduction of air spaces of less than $\frac{3}{8}$ in. width when 8 in. high. Fig. 6 shows the manner in which the resistance of air spaces is affected by temperature difference. The curves are plotted for resistance corresponding to conduction per degree difference in temperature. The less the temperature difference the greater the resistance. The conductivities and conductions of air spaces of various widths for various differences of temperature are tabulated in the original article. The effect of varying heat upon the resistance of air spaces of various widths is shown by curves. A curve showing variation of conductivity of vertical air spaces with height when the temperature differences are small and the widths not greater than the width of maximum resistance for each particular height seems to indicate that for heights greater than 2 ft. (width of space remaining the same) the conduction changes very little. However, this conclusion is an extrapolation not yet verified by experiment.

A knowledge of the conduction of air spaces and rigid insulators enables one to compute the conduction of almost any compound wall by adding the reciprocals of the conductions, *i. e.*, the resistances of the various parts. It is true that the conduction of a wall containing air spaces depends upon the temperature difference, unless the air spaces be less than $\frac{1}{2}$ in. wide. But the variation of conduction with temperature difference is not large enough to prevent the computation of wall conductions for usual conditions to within reasonably close limits. The data presented above explain some apparent contradictions. For instance, it has long been assumed that for practical purposes all air spaces in wall construction have about the same conduction. This has been approximately true for air spaces less than $\frac{7}{8}$ in., but the suggestion has been made that increasing the number of air spaces at the expense of their width would give any desired amount of insulation in a given space. This is not true because the conduction is no longer the same for spaces below $\frac{1}{2}$ in. in width, and increases almost in proportion to the decrease in width below this figure, so that practically nothing is gained by making air spaces narrower than this.

The writers show that, in the construction of walls such as those of refrigerator cars in which air spaces are employed, when the total air space available is 1 in. or more in width, a decided advantage is gained by so distributing the material that it splits this air space into two or more parts.

The paper briefly discusses the conductivity of rigid insulators and the methods of testing such insulators. The Bureau of Standards expects in the course of a few months to have secured and tested samples of the important commercial insulators. In fact, data of tests of some of these insulators are given in a table in the appendix. (*A. S. R. E. Journal*, vol. 3, no. 2, page 5, September, 1916, 21 pp., 5 figs. *eA.*)

THE SMALLEST COOPER SYSTEM COLD-STORAGE PLANT

Description of a plant installed by the Iowa State Agricultural College at Ames, Ia., for experimental purposes, especially in connection with fruit research work. The refrigerated space is quite small. As it was desired to secure several different temperatures, small chambers controlled by thermostats were placed within the cooling chamber. These small chambers are so arranged that by maintaining the cooling chamber at the maximum low point required, heat may be applied in the small chambers and thereby any higher temperature desired may be maintained therein.

It is stated that in addition to experiments on the respiration of fruits at various temperatures, experiments have also been made on germination. In these latter experiments seeds which require a low temperature for germination have been placed within the small chambers controlled by thermostats, the aim being to determine the minimum, maximum and optimum temperatures required for germination. (*Cold*, vol. 7, No. 12, page 135, October 1916, 2 pp., 3 figs. *d.*)

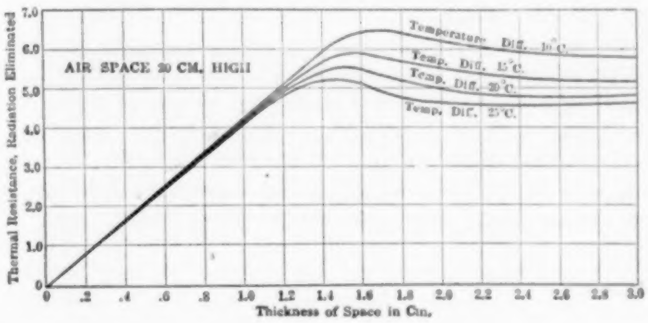


FIG. 6 THERMAL RESISTANCE OF AN AIR SPACE OF CONSTANT HEIGHT, IN CAL. PER HR. CM^2 PER DEG. CENT. (ORDINATES)

THE FLOW OF SUPERHEATED AMMONIA GAS IN PIPES, Edward F. Miller

The paper gives in condensed form the results of an investigation made by Edward A. Whiting and Edward H. Williams, class of 1916, Massachusetts Institute of Technology, and presented by them as their thesis.

The tests from which the data referred to in the paper were compiled were undertaken to obtain sufficient data on the flow of superheated ammonia in a pipe open to the air, from which, taking into account the length of the pipe, the necessary size of the discharge of a safety valve might be determined.

The experiments were all made on Beyers pipe 1.5 in. in diameter. The orifice used for measuring the flow was 0.5 in. diameter with the curve 0.25 in. radius at entrance, the straight part of the orifice being 0.75 in. long. The pressure in the orifice was obtained through an opening 1/32 in. diameter drilled at right angles to the straight part of the orifice. Experiments were run with the head pressure varying by 25 lb. from 50 lb. gage through 200 lb. gage, with pressures at the entrance to the 1.5-in. pipe varying from 31 lb. absolute to 67 lb. absolute and temperatures from 141 to 171 deg. fahr. The results are given in the form of two capacity drop curves, one for a pipe with tees and the other with no tees.

A formula deduced to fit the experiments on $1\frac{1}{2}$-in. pipe with tees in the line was given as

$$W = 1.6\ D \left(\frac{100\ d}{L}\right)^{.518}$$

where D = density at entrance,
d = pressure drop in pounds for length L,
L = length of pipe in feet,
W = weight per second in lb.

Probably there will be but little error if this formula is put into the form given below, so as to make it apply to pipes from 1 in. to 2 in. diameter.

$$W = 1.6\ D \left(\frac{100\ d}{L}\right)^{.518} \frac{b^2}{2.25}$$

where b = diameter of pipe in inches.

The Babcock formula with a constant deduced from these experiments becomes

$$W = 2.37 \left[\frac{d\ D\ b^5}{\left(1 + \frac{3.6}{b}\right) L}\right]^{\frac{1}{2}}$$

These formulæ, if applied in figuring the discharge capacity of 100 ft. of pipe on the outlet of a safety valve having inlet and outlet pipes of the size called for by the refrigeration regulations in force in Massachusetts, show that in every case the pipe has a discharging capacity at least 50 per cent greater than the rated capacity of the valve. (*A.S.R.E. Journal*, vol. 3, no. 2, p. 26, September 1916, 3 pp., 1 fig. *et.*)

Research

THE RELATION OF PURE SCIENCE TO INDUSTRIAL RESEARCH, J. J. Carty

President's address delivered at the Annual Convention of the American Institute of Electrical Engineers at Cleveland, Ohio, June, 1916.

The writer traces the growing appreciation of the importance of industrial scientific research primarily to the events in Europe, and the recognition of the unpreparedness of our own country to defend itself against attack. Industrial research conducted in accordance with the principles of science is no new thing in America. The Engineering Department of the American Telephone and Telegraph Company, under the charge of the speaker, was founded nearly forty years ago to develop, with the aid of scientific men, the telephone art, and has grown from small beginnings to a great institution employing hundreds of scientists and engineers. It is generally acknowledged that to industrial research thus conducted we are largely indebted for the telephone achievements in America being so greatly above those of other countries.

The same applies to the development of electric light, electric power and electric traction. Vast sums are being spent annually upon industrial research by some of the larger electrical manufacturing concerns, but the speaker says with authority that these laboratories return to the industries each year improvements in the art which taken all together have a value many times greater than the total cost of their production. Money expended in properly directed industrial research conducted on scientific principles is sure to bring to the industries a most generous return.

Industrial scientific research departments can reach their highest development in those concerns doing the largest amount of business, and small concerns without coöperation among themselves cannot have the full benefit of industrial research, for no one among them is sufficiently strong to maintain the necessary staff and laboratories. But once the vital importance of this subject is appreciated by the small manufacturers, many solutions of the problem will promptly appear. One of these is for the manufacturer to take his problem to one of the industrial research laboratories already established for the purpose of serving those who cannot afford a laboratory of their own. There are now under consideration many plans for the establishment of industrial laboratories to serve concerns which cannot afford laboratories of their own, and in some cases the possible relation of these laboratories to our technical and engineering schools is being earnestly studied.

But until the manufacturers themselves are aroused to the necessity of action in the matter of industrial research, no plan can be devised that will result in the general establishment of research laboratories for the industries.

In the present state of the world's development there is nothing which can do more to advance American industries than the adoption by our manufacturers generally of industrial research conducted on scientific principles. In the minds of many there is confusion between industrial scientific research and purely scientific research, particularly as the industrial research involves the use of advanced scientific methods and calls for the highest degree of scientific attainment. The distinction lies not in the subject-matter of the research but in the motive. Industrial research is always conducted with the purpose of accomplishing some utilitarian end. Pure scientific research is conducted with a philosophical purpose for the discovery of truth and for the advancement of the boundaries of human knowledge. At the same time, while a single discovery in pure science when considered with reference to any particular branch of industry may not appear to be of appreciable benefit, yet when interpreted by the industrial scientist, with whom may be classed the engineer and the industrial chemist, and when adapted to practical uses by them, the contributions of pure science as a whole become of incalculable value to all the industries.

But who is to support the researches of the pure scientist, to furnish the laboratories and the funds for apparatus, traveling and foreign study? It has been suggested that perhaps the theater of scientific research might be shifted from the university to the great industrial laboratories which have already grown up, or to the even greater ones which the future is bound to bring forth. The speaker does not agree with this. Organizations and institutions of all kinds engaged in pure scientific research should receive every encouragement, but the natural home of pure science and of pure scientific research is to be found in the universities, from which it cannot pass. Instead of abdicating in their favor, our universities, stimulated by the wonderful achievements of these industrial laboratories, should find a way to advance the conduct of their own pure scientific research.

The universities, however, are not money-making institutions. Well, there is much that can be done without money. The most important and most fundamental factor in scientific research is the mind of a man suitably endowed by nature, and responsible university authorities should apply their judgment so that when the man with the required mental attributes does appear he may be appreciated as early in his career as possible.

While, however, there are many things and most important things which the universities can do to aid pure science without the employment of large sums of money, there are, nevertheless, a great many things required in the conduct of pure scientific research which can be done only with the aid of money, and the first of these is to provide a master scientist,

when he does appear, with all the resources and facilities and assistance, so as to afford a full freedom of development to the range of his genius.

Workers in pure science should be located not only in our great universities, but also at our technical schools, where the influence of a discoverer in science would serve as a balance to the practical curriculum and familiarize the student with the high ideals of the pure scientist and with his rigorous methods of investigation.

The engineering student should be taught to appreciate the ultimate great practical importance of the results of pure scientific investigation and to realize that pure science furnishes to engineering the raw material, so to speak, which must be worked into useful forms. A better understanding is required of the relation between the pure scientist and the applied scientist, and this understanding would be greatly helped by a closer association between the pure scientist and the student in the technical schools. (*Proceedings of the American Institute of Electrical Engineers*, vol. 35, no. 10, p. 1411, October, 1916, 10 pp., *g.*)

Concerning Efficient Means for Establishing a Connection Between Science and Industry, A. Blondel

In a recent sitting of the French Academy of Sciences a member, Le Chatelier, presented a paper on the necessity of establishing in France a closer relation between the work of pure scientists and the industrial activities of the country.

It appears that in France the prevailing tendency is for savants to keep aloof from practical activities, and the Academy of Sciences has no section devoted to practical engineering of today.

The author of the present article, A. Blondel, chief engineer of the Department of Bridges and Roads, and also member of the Academy of Sciences, emphasizes still more the necessity of such a coöperation.

He points out that the French Academy even now includes such sections as geography and navigation and medicine, which points to the desire of the founders to include in the scope of the activities of the Academy practical engineering, at least practical engineering of those days. Since then, however, engineering has developed without a corresponding growth in the scope of the work of the Academy.

He therefore suggests the creation of sections of industrial engineering, applied and constructive mechanics, applied chemistry and industrial physics. It appears that the part of the Academy of Sciences in bringing together the pure scientist and the engineer is particularly important in France. There are certain technical societies such as the Society for the Encouragement of National Industry, the Society of Electricity, the Aeronautical League and the Society of Civil Engineers, but the first three of these societies admit members practically on their payment of dues, that is, without imposing effectively strict qualifications of admission, while the Society of Civil Engineers excludes from its membership engineers in the employment of the government. Hence, the higher class of engineers in France has really no common body to work out the larger aspects of engineering activity. (*Sur un moyen efficace d'établir la liaison entre la science et l'industrie*, A. Blondel, *Le Génie Civil*, vol. 69, no. 11, p. 169, September 9, 1916, 3 pp. *g.*)

The National Physical Laboratory—Its Work and Aims, Walter Rosenhain

The writer begins with a discussion of the relation between science and industries, with special reference to conditions existing in Great Britain.

Broadly speaking, scientific activities, from the point of view of their relation to industries, may be divided into three groups or phases which, while they necessarily overlap, yet afford a convenient and rational means of classification. In the first place the application of science to industry cannot be cultivated until we possess the "science" we are to apply. While even the existing body of scientific knowledge, as laid down in scientific publications, is in most fields considerably in advance of technical practice, one cannot rest content with merely this ready-made knowledge. If the application of science is to be fruitful and progressive science itself must also be progressive,—it must be living, growing science. It is as vital to keep abreast, and if possible ahead, of our rivals in pure scientific investigation and discovery as in the practical application of its results.

Experimental Plant

The next phase is the transition from purely scientific to practical work. In order to make experiments which give intelligible results or to obtain data which lend themselves to accurate calculations, the scientific worker is obliged to simplify the phenomena as far as he can. In the laboratory he uses for that particular purpose experimental devices intended to eliminate as far as possible all those disturbing factors in which he is not interested, but when one comes to applying the results obtained by the pure science worker to practical ends an entirely different set of conditions is encountered. For practical purposes we have to deal with natural phenomena as we find them, and have to produce the desired result in an approximate but efficient manner; in other words, we have to translate laboratory results into shop language.

To make this somewhat clearer the author employs a metallurgical example. Suppose an investigator is studying the constitution and properties of a system of alloys of two metals. The proper course for him is to work with the chemically pure metals, or with the nearest approach to them he can obtain. But after the investigation is completed and the technical worker is asked to render the alloy obtained in the laboratory available for practical use, he is probably immediately confronted with the fact that he cannot obtain on the market his metals of the the degree of purity employed by the investigator. Hence, an alloy which proved in the laboratory to be ductile and workable might easily prove brittle and useless when made in the works. In reality both results would be true but both must be more fully understood to be brought into mutual agreement. Further research is required to meet the difficulties which hamper proper application. Either means must be found to eliminate the injurious impurities, or methods of working must be adopted whereby the influence of the impurities is in some way overcome. This part of the work must be done on a proper scale and may entail a much longer series of experiments, requiring elaborate appliances as well as numerous assistants. The erection of such "experimental plants" and their running expenses entail very considerable financial demands.

Industrial Works Organization

The third step or phase in the application of science to industry lies in the industrial works themselves, where the men trained in pure and applied science should find room for their

useful activities. The first step for securing for science its proper status in the industries must be the creation of an adequate appreciation of science and its possibilities among those who control the industries, and the author calls attention in this connection to the fact that in Germany it was quite usual to elect scientific men to the boards of directors of great enterprises.

IDEAL NATIONAL LABORATORY

From this the author proceeds to a discussion of what he calls the Ideal National Laboratory. Such a laboratory would be an institution for research, additional and supplementary to the work of universities and colleges, but one in which the educational bias is entirely absent and whose activities can, therefore, be directed in an entirely untrammelled manner to the solution of problems suggested by public utility, scientific importance, or industrial demand. Such an institution would possess a more or less permanent staff of investigators and their highly trained assistants, thus affording opportunities for long-continued researches which can scarcely be undertaken by a professor working with successive generations of young students. The equipment of such an institution could be designed on lines free from educational considerations; apparatus and experimental plant could be set up, involving, if necessary, the permanent employment of skilled labor as well as scientific supervision. If only one or a very few such institutions were set up in the country, equipment could be carried out on a scale of cost which could not be reproduced at any considerable number of colleges, whereas appliances could be used which it would be unsafe to place in the hands or even within the reach of students.

Such an establishment should occupy a unique position as a central national institution which would naturally undertake certain duties of a scientific or technical nature required by the government. In another direction, where certain industries required national aid on account of their vital nature as "key" industries, the national central institution would provide the government with the means of affording the scientific assistance demanded. The Ideal National Laboratory would be in the closest possible touch with the most advanced scientific thought and would, if it fulfilled its functions properly, contribute largely to the advancement of pure science by utilizing its experimental resources to that end. At the same time, the institution would also be in useful touch with industry, helping, advising, assisting, testing, taking up the special investigations proposed by industry and dealing with them in the laboratory and the experimental plant.

NATIONAL PHYSICAL LABORATORY

An ideal somewhat on these lines has actually been recognized by most of the great nations and each of them has worked out its own institution on characteristic lines. In the United States, as the speaker stated, we see the Bureau of Standards developing into an institution of very great size and of steadily increasing importance. In Britain the National Physical Laboratory was opened in 1901, making a very small and modest beginning at a time when the German national laboratories had already attained great size and reputation.

The National Physical Laboratory is thus not yet 15 years old. At its inception the work was begun in a very tentative way and extensions have been made in a hesitating and guarded manner due to the difficulty with which the Laboratory authorities have obtained the requisite funds from the treasury. The Laboratory is not actually a government institution. It is managed by a committee appointed by the Royal Society, and members of the staff of the Laboratory are employees of the Royal Society and not civil servants. The treasury makes a grant of £7000 to the Royal Society per annum towards the cost of the Laboratory and in return exacts certain conditions in regard to the work. This grant is entirely inadequate for the maintenance of the Laboratory, which is mainly supported by fees earned by itself (a large part of these fees are, however, derived from government sources). Further, technical institutions like the Institution of Mechanical Engineers, Institute of Civil Engineers, Institute of Naval Architects and others have contributed to the Laboratory budget, in some cases by simple donations and more frequently by grants in aid of some definite scheme of research.

The management of the Laboratory rests with an executive committee selected from the general board. On the latter are represented the scientific and technical institutions as well as certain government departments. The Laboratory itself is divided into four great departments dealing with Physics, Engineering, Metallurgy and Metallurgical Chemistry and the National Experimental Tank.

The Laboratory serves also as the official laboratory of the Advisory Committee on Aeronautics, and the aeronautical work carried out in the Engineering and Metallurgy departments constitutes an important separate division in each.

Besides the director, superintendents (prominent engineers and scientists) and principal assistants, there is a large staff of scientific assistants of various grades, as well as a large staff of others less highly trained but often of very great value and experience who are classed as "observers," and in addition to this there is a complement of skilled workmen. Quite recently the policy of employing women on both the "scientific" and "observer" staffs has been initiated, and so far the result promises to be eminently satisfactory, although in the majority of cases women have merely been appointed to temporary posts during the absence of men on military service.

ENGINEERING RESEARCH

Naturally the section most interesting to engineers is the Engineering Department, which comprises practically four sections devoted respectively to testing materials; testing and standardization of engineering apparatus, appliances, and machines; testing and investigation of road materials and roads, and aeronautics. All these sections work in close conjunction with the metallurgical department and which deals with all *materials* as such.

One important result of the work in the Section of Testing of Materials has been the development of whole series of machines for the application of various mechanical tests to metals, and recently some of these have been extended to concrete and timber. Among these methods of testing those known as "dynamic" in contradistinction to the ordinary so-called "static" tensile test have received the most attention. One of the first dynamic tests studied was the alternating stress test, in connection with which a machine has been developed for applying alternate tension and compression to small test pieces, thus exposing them to alternations of direct stress in place of the alternate bend action which occurs in the original Woehler test. This led to an increased use of testing by means of direct alternating stresses, and incidentally it

has been shown that the time occupied by tests can be very much reduced as it has been found that an increase in the speed of alternations up to 2200 per minute does not affect the results of the tests.

Another form of test developed in the Laboratory is that in which a notched test piece is exposed to blows of a hammer of known weight falling from a known height and alternately striking the test piece on opposite sides.

Results obtained from alternating stress tests of various kinds have led to the view that so long as a material is only exposed to stresses which nowhere exceed the true elastic limit, the material will resist an indefinite number of alternations; but so soon as plastic deformation is produced, even in a few isolated crystals, then failure will sooner or later occur under a sufficiently long-continued repetition of stresses. This led to an extremely interesting investigation on the subject of elastic limit.

The work of the Aeronautical Section has been touched upon only very slightly because of the secrecy covering all developments since the beginning of the European war. In general the work may be described as being of two kinds, first, a series of continued investigations for the purpose of establishing the fundamental principal data and formulæ which must govern aircraft design, and second, testing actual models with a view of ascertaining their properties and behavior in the air.

Both lines of aeronautical work are pursued by means of scale models and the equipment of the Laboratory consists largely in appliances for measuring the forces acted upon or exerted by these models when in motion relative to the air at known speeds.

The development of aeronautics has practically created what has become known as the chemistry of aeronautics, which has already assumed a very high degree of importance. Apparatus had to be designed, for example, for testing balloon or airship fabrics for the power of retaining hydrogen gas. (*The Journal of the West of Scotland Iron and Steel Institute*, vol. 23, No. 6, p. 213, April, 1916, 66 pp., 32 figs. *dA.*)

Steam Engineering

Boiler Expansion Experiments, D. R. MacBain

Data of tests made on the New York Central Railroad system to determine relative movements of firebox sheets and tubes under working conditions.

From experiments made at various times it was found that the expansion of the outer sheets was greater in every case than that of the inner sheets, which would seem to account for the breakage of the back head and throat sheets along the outer row of staybolts, also for the vertical cracks in the side sheets as well as the cracks extending from the arch tube holes.

It was also found by means of a needle connected with the inner throat sheet and passing through the outer throat sheeet that the inner tube sheet moved outward 3/32 in. when the fire was first started and before the circulation was fully established, and later, when steam pressure began to rise, backward about 1/16 in. The first movement throws some light on the cause of the side sheet cropping out along the fire line, as it does sometimes.

Another source of trouble was found with the breakage of staybolts in some of the wide firebox engines.

It was believed previously that the cause of these bolts breaking was the same as that which was responsible for the leaky side sheet seams, and further that the elimination of excessive staybolt breakage would result in a cure for these leaky seams. With rigid bolts it was quite common to find anywhere from three to five or more bolts broken. An experiment was therefore tried on an Atlantic-type engine while it was undergoing repairs. A heavy template was fitted from the side of the boiler when the boiler was cold and was firmly clamped at its center to the boiler. The fit was very carefully made. The engine was then fired up and the effect of

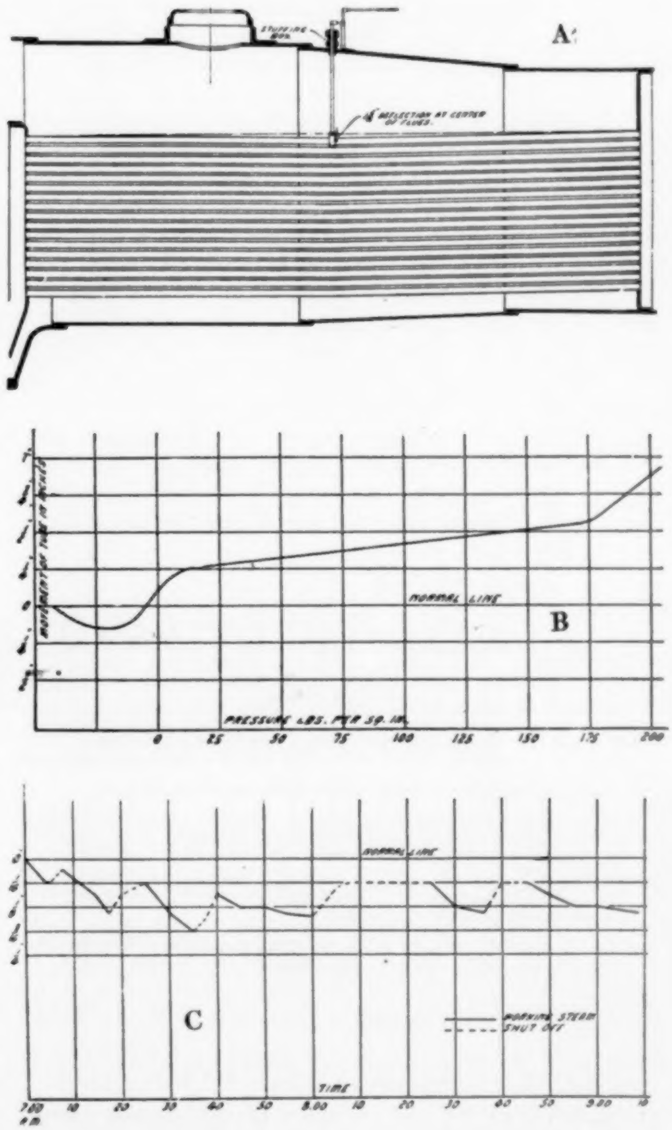


Fig. 7 Arrangement of Pointer in Boiler Tube Deflecting Test. Curves Showing Movement of Tube: B. Boiler Fired up without Blower; C. Road Service, West Albany to Rotterdam Junction

heating up the boiler to the point where 200 lb. of steam was obtained caused the wrapper sheet to bulge out so that there was 3/32 in. opening between the template and the wrapper sheet at both ends of the template. This apparently explains the cause of the breakage of the staybolts.

In order to determine whether this distortion of the boiler was caused by the pressure or the heat, the template was carefully refitted and a pressure of 225 lb. of cold water put on the boiler. The template retained its shape, which proved conclusively that the distortion was due to the temperature and

not to the pressure. The application of three rows of flexible staybolts stopped the trouble and cured the leaky seams.

The New York Central has also made experiments to determine why the back and front tube sheets become deflected or distorted. It was believed that while the boiler was working and had a hot fire the expansion in the boiler proper, that is, between the tube sheets, was greater than in the tubes. An experimental set of tubes was installed in a large Pacific-type locomotive, each tube being given a drop of 15/16 in. at the center, but fastened at each end. A rod was fastened to one of the top tubes at the center and extended up through a stuffing box in the boiler shell, as shown in Fig. 7A, the outer end being attached to a recording device which would register the movements of the tube. Fig. B shows the result of a standing test from the time the fire was started until 200 lb. pressure in the boiler was obtained. Almost immediately after the fire was started the tube deflected still more until it had reached 1/8 in. It remained in this position for a short time and then it rose and was about 1/8 in. above its normal position when the steam pressure began to rise. It rose gradually until 175 lb. pressure, and then rose rather abruptly. This rapid rise may have been due to the needle sticking a little in the stuffing box. Fig. C is the record of another test, namely, on a road trip from West Albany to Rotterdam Junction. The solid lines are readings taken when the throttle was open, and the dotted lines with the throttle closed and the engine drifting. It is seen that immediately upon starting the tubes began to deflect, and rose when the engine was not working steam.

An investigation was also made to determine the direction and extent of expansion in a tube sheet resulting from prossering a set of new tubes. A circle of as large diameter as possible was described on the tube sheet, and after the tubes had been set it was found that this circle had increased or had widened out 1/32 in. at the side and bottom and 3/32 in. at the top. It has been the experience there that the 3-in. radius for the tube-sheet flange will give better results than the 2-in.

Data on the relative movements of the back tube sheet to the throat sheet are given for the time from the moment the boiler is heated up and raised to 200 lb. pressure and released back to zero pressure. It was found that it is necessary to allow some freedom to the sheets longitudinally in order to avoid excessive strains being set up.

A process is shown for patching the top of a tube sheet that had been cracked from the top of the tube holes up to the flange. (*Railway Mechanical Engineer*, vol. 90, no. 10, p. 496, October, 1916, 41 pp., 13 figs. *e*.)

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society. The Editor will be pleased to receive inquiries for further information in connection with articles reported in the Survey.

SELECTED TITLES OF ENGINEERING ARTICLES

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DIAGRAMME LOGARITHMIQUE D'ENSEMBLE APPLICABLE AU CHOIX D'UNE HÉLICE, G. Eiffel. L'Aérophile, vol. 24, no. 15-16, August 1-15, 1916, 4 pp.
Logarithmic diagram for use in the selection of a propeller.

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The present state of aerodynamics, aerial article.

FAUT-IL CONSTRUIRE DES ZEPPELINS? A. Poidloué. L'Aérophile, vol. 24, no. 15-16, August 1-15, 1916, 1½ pp.
Is it necessary to build Zeppelins?

LES BI-MOTEURS ALLEMANDS A. E. G., Jean Lagorgette. L'Aérophile, vol. 24, no. 15-16, August 1-15, 1916, 1½ pp., 5 figs.
Twin-engine German aeroplanes.

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LA SIMILITUDINE MECCANICA, Letterio Laboccetta. Rivista di Aeronautica, vol. 10, no. 5-6, December 31, 1915, 6½ pp.
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RELAZIONE FRA LA VELOCITÁ DEL VENTO, Giuseppe Crestani. Rivista di Aeronautica, vol. 10, no. 5-6, December 31, 1915, 3 pp., 2 figs.
Velocity of wind phenomena.

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Hydrodynamic experiments.

RICERCA DI UN PROPULSORE AEREO. Rivista di Aeronautica, vol. 11, no. 1-2, April 30, 1916, 5 pp., illustrated.
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AUTOMOBILES

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BRAKE DESIGN NOT UP TO PAR, A. Ludlow Clayden. The Automobile, vol. 35, no. 13, September 28, 1916, 2½ pp.

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